Department of Mines.

NEW ZEALAND GEOLOGICAL SURVEY.
(J. M. BELL, Director.)

QE 348.2 B3+ no. 4

BULLETIN No. 4 (NEW SERIES).

THE GEOLOGY
OF THE
COROMANDEL SUBDIVISION,
HAURAKI, AUCKLAND.

BY
COLIN FRASER,
ASSISTED BY
JAMES HENRY ADAMS.

ISSUED UNDER THE AUTHORITY OF THE HON. JAMES McGOWAN, MINISTER OF MINES.

NEW ZEALAND.
BY AUTHORITY: JOHN MACKAY, GOVERNMENT PRINTER, WELLINGTON.

1907.

LETTER OF TRANSMITTAL.

Geological Survey Office,

Wellington, 1st November, 1907.

Sir,—

I have the honour to submit herewith Bulletin No. 4 (new series) of the New Zealand Geological Survey.

This Bulletin covers a report on the geology of the Coromandel Subdivision, Hauraki, Auckland, by Mr. Colin Fraser, Mining Geologist, assisted by Mr. James Henry Adams.

The volume comprises 154 pages of letterpress. It contains 11 maps and 2 sheets of sections, and is illustrated by 33 plates.

I have the honour to be,

Sir,

Your obedient servant,

J. M. BELL,

Director.

Hon. James McGowan,

Minister of Mines,

Wellington.

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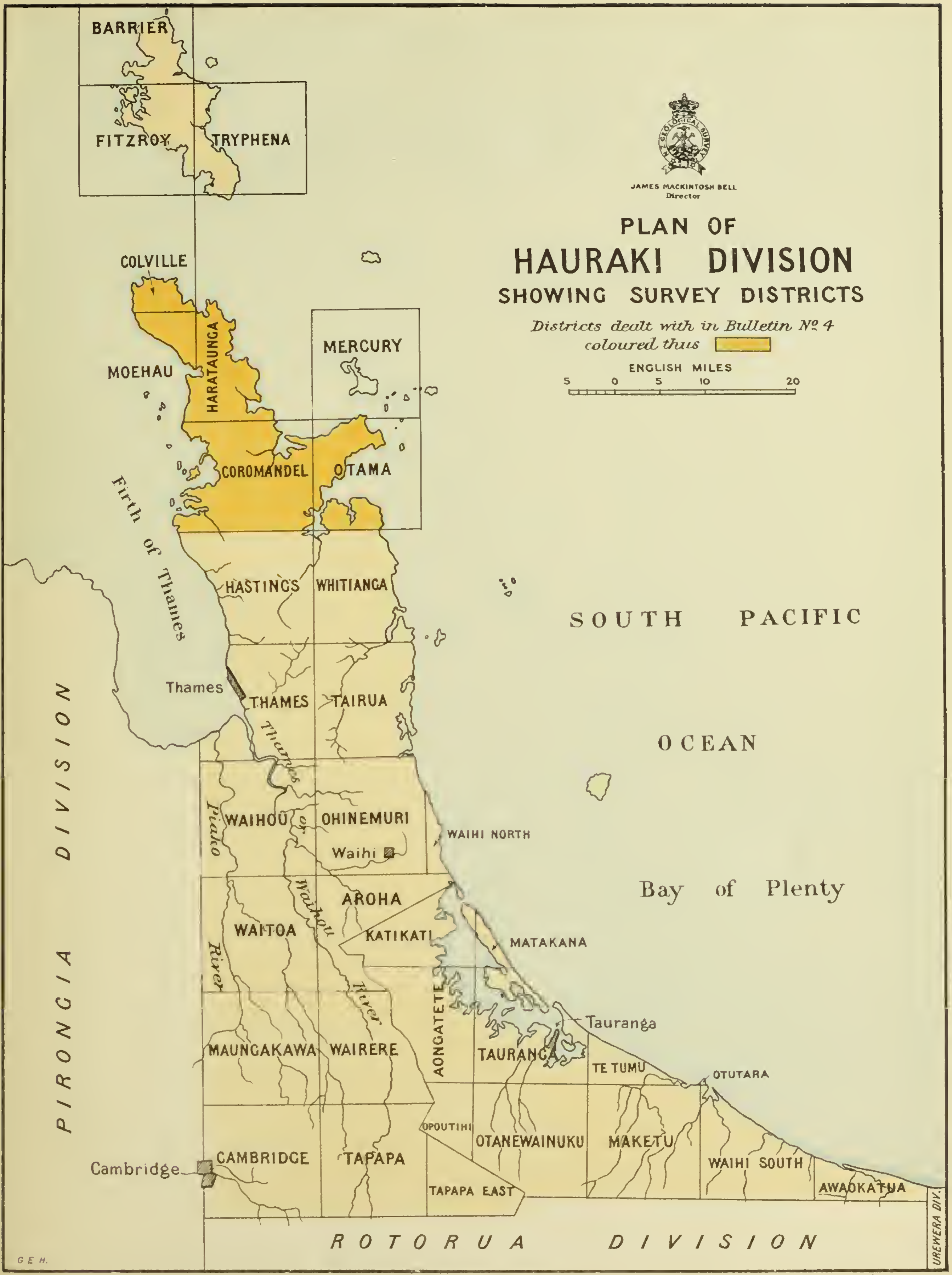

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BULLETIN No. 4 (NEW SERIES).

THE GEOLOGY

OF THE

COROMANDEL SUBDIVISION,

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CHAPTER I.

GENERAL INFORMATION.

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INTRODUCTION.

THE Hauraki Division lies between latitudes 36° south and 38° south on the eastern side of the North Island of New Zealand.

This division includes within its boundaries the Cape Colville Peninsula,* a contiguous portion of the mainland to the southward, from which the peninsula has its extension, and several small islands each located within short distances of the coast-line of the peninsula. The Great Barrier Island (106·8 square miles) and the Great Mercury Island (6·67 square miles) are the most important of these insular areas.

The division is bounded to the north and east by the wind-swept waters of the Pacific Ocean. To the westward its peninsular shore-line is washed by the sheltered waters of the Hauraki Gulf and Firth of Thames. From the south shore of the latter physical feature an arbitrary line extending due southward marks the western boundary of this portion of the area. This line, which is 52 miles in length, passes across the alluvial plains west of the Piako River, and terminates a short distance south of the Town of Cambridge. From the southern extremity of this meridional line, a line passing due east for 34 miles, then north-north-east for 3 miles to Mount Puwhenua, then from Mount Puwhenua due east to the shores of the Bay of Plenty, a distance of about 45 miles, determines the boundary between the Hauraki Division and the Rotorua or Hot Lakes Division. This southern boundary-line throughout its whole course traverses undulating and hilly country. The Hauraki Division is thus roughly triangular in shape, and, together with the several small outlying islands, covers an extent of 2,952·97 square miles.

The Hauraki Division constitutes at the present time the most important gold-mining area in New Zealand. In its southern portion is located the Waihi Mine, which now ranks among the world's greatest gold-producers, while further north lie the mining centres of Thames and Coromandel, both

* This peninsula is also known as Coromandel Peninsula, and as Hauraki Peninsula.

famous for the great bonanzas of their auriferous quartz veins. The area from a geological point of view is a wonderfully interesting one, presenting on a grand scale all the evidences of vulcanism and attendant solfatarism of former geological times. A Tertiary volcanic complex, referable to several periods of eruptive activity, overlies folded and denuded sedimentary formations. The extrusion of the volcanic materials, which form masses of considerable thickness and areal extent, has been intimately connected with orogenic movements.

The consideration of its structure, petrology, and ore-deposits, shows that the Hauraki area presents many striking resemblances to the Washoe, Cripple Creek, and Tonopah mining districts of the United States of America, and to the ancient mining-field of the Hungarian province of Transylvania in Europe. The further study of the Hauraki veins and their surroundings may be expected to throw additional light on the important and fascinating problems connected with ore-genesis.

Area described in this Bulletin.

The Hauraki Division has for the purposes of convenience in survey been marked off into four subdivisions. These, considered in order from north to south, have been named the Coromandel subdivision, the Thames subdivision, the Waihi subdivision, and the Tauranga subdivision. Geographically considered, the principal mining centres of the Hauraki Mining District fall into three areas, and these areas practically coincide with the first three of these subdivisions — namely, Coromandel, Thames, and Waihi.

The Coromandel subdivision, which consists of the Survey Districts of Colville, Moehau, Harataunga, Coromandel, and Otama, as laid out by the Lands and Survey Department, is the area described in this bulletin. It forms the northern portion of the peninsula and stretches southward from Cape Colville for a distance of 28 miles, to a line extending due east from a point near Kirita Bay on the western coast-line, to Hot Water Beach on the eastern coast-line. The Coromandel subdivision as thus defined covers an area in all of 307·89 square miles.

The Great Barrier, the Great Mercury, and certain other outlying islands are not included in the area considered in the present report. The examination collectively of these and all the other islands in the neighbourhood of the peninsular coast-line can be more conveniently undertaken apart from the mainland at a later date, before the preparation of the completed monograph on the Hauraki Division.

Officers connected with the Field-work.

The field examinations upon which this bulletin is based have extended over a period of some seventeen months (October, 1905 – March, 1907), and are referable to the individual work of several investigators.

Dr. J. M. Bell, Director of the Geological Survey, initiated the survey in October, 1905, when he conducted the field-work in the extreme north-western portion of the area. From this date to the end of the year the work had his personal supervision.

The senior writer of this bulletin, who joined the field party on the 7th of November, 1905, assumed charge of operations on the departure of the Director from the field, and, with the exception of the period from February to August, 1906, when assisting in the field elsewhere and in office-work in connection with the preparation of Bulletin No. 1 (Hokitika Sheet, North Westland), he was continuously engaged in this capacity in the Coromandel subdivision.

For the first eight months of the year 1906, Mr. E. J. H. Webb, and since that period Mr. J. H. Adams, both now Assistant Geologists of the Survey, performed the duties of assistants on the Hauraki field staff. During the six months' absence of the senior writer from the field Mr. Webb continued the operations during a rather inclement winter season, in an area lying to the east of the main mountain divide and extending from Port Charles to the southern watershed of Kennedy's Bay Valley.

In addition to the several permanent officers of the Geological Survey Staff, Mr. D. V. Allen, Director of the Coromandel School of Mines, was engaged to assist in the field-work for two terms of six weeks each. During the first of these periods Mr. Allen was engaged in the study of the Cabbage Bay district, while in the second period the examination of the Te Pungapunga and Whangapoua Valleys was assigned to him.

Acknowledgments.

A great number of the scenic illustrations contained within the pages of this report are from photographs taken by Mr. Alexander McKay, while the micro-photographs illustrating the petrography of the area are the expert work of this geologist. For these favours, and for valuable information afforded the writers by Mr. McKay, who has an intimate knowledge of the geological conditions in the Hauraki area, grateful appreciation is formally expressed.

To Dr. J. S. Maclaurin, Colonial Analyst, and his staff, all the analyses quoted in this bulletin, except where stated to the contrary, are referable, and for the expeditious manner in which the various reports were furnished, the writers wish to record their cordial thanks.

The thanks of the Geological Survey Department are especially due to the private mine-owners and to the attorneys, legal managers, and mine-managers of the several companies controlling the mining interests within the boundaries of the Coromandel subdivision. All were without exception most courteous in placing at the disposal of officers of the Survey the plans of their respective mines, and in facilitating in every way the examination of the underground and surface workings.

In connection with the mine-workings at present abandoned, much accurate information was voluntarily supplied by Mr. John Reilly, C.E., land and mining surveyor, a favour which is gratefully acknowledged.

Conditions of Geological Work and Method of conducting Field Operations.

The general conditions within the Coromandel subdivision are not so favourable for geological investigation as might at first sight be expected from considerations of its latitude and physiography.

The volcanic material which takes such a large part in the structure of the peninsular mass is subject to rapid surface decomposition : the crests and slopes of the ranges are therefore covered with a comparatively thick mantle of disintegrated rock, which effectively conceals the contacts of the various formations. As regards vegetation, the thick matted undergrowth which characterizes much of the New Zealand forest is here greatly in evidence, and constitutes a very effective barrier to geological investigation and mineral-prospecting. Forest vegetation continues to the greatest elevations met with in the subdivision, so that the traverse even of the crests of the wind-swept Moehau Range (elevation 2,000 ft. to 2,935 ft.), was, owing to the almost impenetrable nature of the mountain scrub, a matter of considerable difficulty.

Very fair natural sections are exposed along the coast-line, and this was therefore examined in detail. Along the coastal belt, however, the older volcanic rocks, which constitute the principal auriferous series, are overlain by the products of a later period of volcanic activity, and are therefore seldom encountered.

The beds of the main streams and of their tributaries afford the best outcrops for aiding the geologist in the mapping of the various formations. Where, however, these watercourses traverse areas of altered and consequently easily eroded andesitic rocks, outcrops are often rare, owing to the large amount of recent débris in course of transport. Within the actual mining centres the examination of all available underground workings, and also of the plans in possession of the various mining companies, afforded much information. It is very unfortunate, however, that during the progress of the present survey the mining industry of this district was experiencing one of its periods of temporary depression, and, consequently, in no claim was mining being carried on below the level of the ground-water, owing to the cessation of pumping operations. Seeing that very many of the rich ore-shoots, which have made some of these mines famous, occurred below the water-level, it is a matter of regret that further geological examination in this direction was precluded.

Much of the information in this bulletin, relating to mining conditions in the lower levels, has been gleaned from various official plans and records, and from reliable persons who have had direct connection with actual mining operations. The recorded observations of previous geological investigators have also been of value in this connection, as well as the senior writer's intimate personal acquaintance with the mines during a period when active operations were in progress. In the carrying-out of the field-work every effort has been made to make the examination as thorough

as possible. The accurate location of the geological and topographical features necessitated a great amount of traversing. The ordinary county map on a scale of 80 chains to the inch, as issued by the Lands and Survey Department, was used as a basis for the mapping, but an inspection of the maps accompanying this bulletin will show that the topographical information has been greatly amplified by the present survey.

The coast-line, which has a total length of some 190 miles, was surveyed in detail. The main streams, together with many of their tributaries, were carefully traversed, and, in addition to an inspection of the various rock-outcrops encountered therein, a careful examination of the stream-débris was carried out, for the purpose of delineating the areas in which auriferous veins may reasonably be expected to occur.

Although, as already indicated, rock-outcrops on the more elevated country are few and far-between, ascents were made of all the conspicuous peaks of the main divide. The greater part of the main water parting between the peaks, in addition to many of the subsidiary ridges and spurs, was also traversed.

Fauna.

The Coromandel subdivision, in common with all other parts of New Zealand, contains no indigenous mammalian life, the short-tailed bat (*Mystacops tuberculatus*) excepted ; but it is one of the few localities that shields from extinction that wonderful and interesting reptile the tuatara lizard (*Sphenodon punctatus*), the sole living representative of the reptilian fauna of Triassic times. On the peninsula, or mainland portion of the Hauraki Division, this giant lizard is believed to be extinct, but it is found on the Great Mercury, and on other of the outlying islands included in the subdivision. One or two smaller varieties of lizards are, with the exception of birds, the bat above mentioned, and a species of frog, the only other land vertebrates existent within the area.

Indigenous birds are at the present time apparently less numerous in the Coromandel subdivision than in former years. Members of the Geological Survey party, whose work was principally confined to the watercourses in the deeper recesses of the bush, were frequently forced to remark on the stillness of the forest and the general absence of bird-life. Excursions, however, to the higher country, the crests of the mountains and ridges, partly dispelled this impression.

The larger of the birds of flight met with in the forest are the pigeon or kereru (*Carpophaga novæ-zealandiæ*), the kaka (*Nestor meridionalis*), the parson-bird or tui (*Prosthemadera novæ-zealandiæ*), the morepork or New Zealand owl (*Ninox novæ-zealandiæ*), and less frequently the makomako or bell-bird (*Anthornis melanura*).

Among the smaller species, the black and pied fantails (*Rhipidura fuliginosa*, *R. flabellifera*), the silver-eye or blight-bird (*Zosterops cærulescens*), and the tomtit (*Petrœca toitoi*) are common ; while the long-tailed New Zealand cuckoo or koekoea (*Urodynamis taitensis*) is also seen from November to the end of January.

The interesting flightless birds of New Zealand are here represented by the North Island woodhen or weka (*Ocydromus greyi*) and the brown kiwi (*Apteryx bulleri*). The former, which inhabits the forest and the clearings fringing the forest, is much less numerous and more timid than the South Island species (*Ocydromus australis*). The curious and characteristic call of the kiwi is seldom heard, and this bird is evidently fast becoming extinct in the area.

In the lowlands and swamps the pukeko or swamp-hen (*Porphyrio melanonotus*) is occasionally seen, and also the hawk (*Nesierax australis*), while the lagoons and lower reaches of the streams are the haunts of the grey duck (*Anas superciliosa*), the brown duck (*Anas* [*Elasmonetta*] *chlorotis*), the teal (*Fuligula novæ-zealandiæ*), the cormorant or shag (*Phalacrocorax varius*), and the kingfisher (*Halcyon vagans*).

On the coast-line abounds the variety of gulls, snipe, sandpipers, &c., common to this part of New Zea and.

Insect-life is fairly abundant, including various varieties of flies, moths, butterflies, ants, caterpillars, centipedes, spiders, &c. The mosquitoes and sandflies are the greatest pests in this category, but most dreaded is a small though comparatively rare spider, the katipo (*Latrodectus katipo*), whose bite is decidedly poisonous, and may even occasionally prove fatal.

Amphibians are represented by the rare New Zealand frog (*Liopelma hochstetteri*), which is found in very few other localities in the colony. This animal, though by no means common, has been found from time to time in the vicinity of Te Moehau Mountain.

Native fresh-water fishes are limited to eels (*Anguilla australis*, *A. aucklandi*), Maori trout or kokopu (*Galaxias fasciatus*), crustaceans in the shape of a small crayfish (*Paranephrops*), and a variety of shrimp. The marine fish characteristic of the northern part of New Zealand are abundant, and some of the more important will be mentioned in connection with the fishing industry.

Introduced mammalian life includes, in addition to the ordinary farm and domestic animals, rabbits, weasels, rats, and mice. The wild bush-pigs, the flesh of which affords a welcome addition to the food-supply of the bushman, are the progeny of animals which escaped from the settlements, and in part, it is said, of animals liberated by Captain Cook's party, which landed at Mercury Bay in 1769. Goats and cattle are in certain localities found running wild in the more remote parts of the forest.

The various birds which have been acclimatised, and are now common to the greater part of New Zealand, exist here. Among these may be mentioned the pheasant (*Phasianus colchicus*) and the Californian quail (*Callipepla californica*), both imported for game, also the well-known small birds—sparrow (*Passer domesticus*), thrush (*Turdus musicus*), lark (*Alauda arvensis*), blackbird (*Turdus merula*), goldfinch (*Carduelis elegans*), yellowhammer (*Emberiza citrinella*), starling (*Sturnus vulgaris*).

The most suitable streams of the Coromandel area have within the last few years been stocked with the rainbow trout. In the small tributaries of the Mahakirau River, and to a lesser extent in the main river itself, these fish, varying up to 7 in. in length, are to be seen. The efforts of the Acclimatisation Society therefore promise to be rewarded within a few years by the trout-fishing which this fine stream should afford.

Flora.*

The Cape Colville Peninsula, as might be inferred from its physiographic features, mild climate, and abundant rainfall, affords conditions particularly favourable for the growth of forest vegetation. As a result of this, the plant life is luxuriant, and in point of variety the forest compares favourably with that of any other part of New Zealand.

Within the Coromandel subdivision considerable areas have, of course, been deforested for the purpose of settlement and cultivation, while all the accessible portions of the remaining bush have been depleted of their marketable timber. The felling and removal of the kauri-pine (*Agathis australis*), a valuable building-timber which formerly grew in great abundance, necessitated partial cutting and clearing of much of the forest. The timber-getter was usually followed by the kauri-gum digger, who sometimes resorted to further clearing and even to burning in order to facilitate his operations. After the lapse of a few years the areas partially deprived of their primeval growth become covered with a dense and almost impenetrable secondary growth, which is the bane of the mining prospector and the backwoodsman. Only in the less accessible portions of the area is the forest found in its virgin condition.

A gradual change in the character of the vegetation is noticeable to an observer as he ascends from the coast-line to the summits of the higher ranges.

On the actual coast-line the muddy flats of the sheltered inlets are being reclaimed by the growth of *Avicennia officinalis* (mangrove), while the inner portions of the sand-dunes of the exposed coast-lines are frequently bound by *Scirpus frondosus*, *Carex pumila*, Spinifex, and *Convolvulus soldanella*. The rocky portions of the coast-line are the habitat of *Metrosideros tomentosa* (pohutukawa), which, however, also grows on the sandy beaches. With this tree, in the former localities, occur *Pittosporum crassifolium*, *Coprosma baueri*, and *Astelia banksii*, while *Sicyos angulatus* and *Bidens pilosa* are less often seen. Near the sandy beaches *Isolepis nodosa* and *Calystegia soldanella* are usually common. The pohutukawa frequently grows with a considerable portion of its trunk bent over and touching the ground, and is particularly conspicuous during the summer months owing to the abundance of its brilliant scarlet blooms.

* The writers are indebted to Mr. T. F. Cheeseman, the author of "Manual of New Zealand Flora," for information relating to the flora of the subdivision.

It is interesting to note that *Fuchsia procumbens, Veronica pubescens,* and *Pisonia brunoniana,* seen in a few places along the coast, are rare plants which were collected by the first botanists in New Zealand.

In the swamp ground the most common plants are *Drosera binata, Haloragis micrantha, Hydrocotyle asiatica, Lobelia anceps, Juncus planifolius, Typha angustifolia* (raupo), *Sparganium simplex, Cyperus ustulatus, Eleocharis acuta. Cladium glomeratum.*

The New Zealand flax (*Phormium tenax*) grows on the rich swamp ground and on the banks of streams ; the allied species *P. cookianum,* easily recognised by its smaller size and long twisted capsules, occurs in places on the shore-line and on the low ridges.

The small areas of level ground at the heads of the various bays, and the alluvial flats by the sides of the streams, often support dense clumps of *Leptospermum ericoides* and *L. scoparium* (manuka, or tea-tree), the trunks of which often exceed 10 in. in diameter ; as a second growth over the whole of the exposed country at low elevations, stunted manuka and *Pteris esculenta* (bracken-fern) are of common occurrence.

The most heavily bushed zone extends from near sea-level to an elevation of about 1,200 ft. The predominant forest-trees are *Elæocarpus dentatus* (hinau), *Dodonæa viscosa* (akeake), *Corynocarpus lævigata* (karaka), *Sophora tetraptera* (kowhai), *Weinmannia sylvicola* (tawhero), *Metrosideros robusta* (rata), *Vitex lucens* (puriri), *Laurelia novæ-zealandiæ* (pukatea), *Beilschmiedia tawa* (tawa), *Beilschmiedia tarairi* (taraire), *Knightia excelsa* (rewarewa), *Agathis australis* (kauri), *Podocarpus totara* (totara), *Podocarpus ferrugineus* (miro), *Podocarpus spicatus* (matai, or black-pine), *Podocarpus dacrydioides* (kahikatea), *Dacrydium cupressinum* (rimu), *D. intermedium.*

Agathis australis (kauri-pine), the most gigantic of the New Zealand forest-trees, was formerly abundant in this area, but now only exists as isolated trees or small clumps in the more inaccessible localities.

The chief plants associated with the above or constituting the undergrowth are clematis, *Melicytus ramiflorus* (mahoe), *Hoheria populnea* (houhere), *Aristotelia racemosa* (makomako), *Dysoxylum spectabile* (kohekohe), *Pomaderris, Coriaria ruscifolia* (tutu), *Rubus australis* (tataramoa, or bush-lawyer), *Myrtus bullata, Fuchsia excorticata* (kotukutuku), *Pseudopanax crassifolium* (horoeka, or lancewood), *Griselinia lucida* (puka), *Coprosma robusta* (karamu), *Olearia cunninghamii, Brachyglottis repanda* (pukapuka), *Dracophyllum latifolium* (neinei), *Veronica salicifolia* (koromiko), *Hedycarya arborea* (porokaiwhiri), *Rhipogonum scandens* (supplejack), *Cordyline australis* (ti), *Astelia solandri, Areca sapida* (nikau), *Freycinetia banksii* (kiekie), *Cyathea dealbata* (ponga), *Pteris scaberula, Lygodium articulatum* (mangemange), *Lycopodium volubile.**

On the crests of the higher ranges the vegetation assumes a different character, and on the summit of the main range south of Te Moehau Mountain the following forms are to be observed : *Drimys axillaris, Melicytus macrophyllus, M. lanceolatus, Elæocarpus hookerianus, Quintinia serrata, Ixerba brexioides, Weinmannia sylvicola, Metrosideros lucida, Myrtus bullata, Fuchsia excorticata, Aleuosmia macrophylla, Coprosma lucida, C. fœtidissima, Senecio kirkii, S. myrianthos, Dracophyllum latifolium, Rhipogonum scandens, Astelia grandis, A. trinervia, Pteris incisa,* and *Polypodium rugulosum.* The largest trees here are *Weinmannia sylvicola* (tawhero), and *Laurelia novæ-zealandiæ* (pukatea).

The peak of Te Moehau (2,935 ft.) is comparatively bare, and is of considerable interest from a botanical point of view, in that it supports a true subalpine vegetation. "Some of the plants found here," remarks Mr. James Adams,† who investigated the flora of the mountain, "are not found nearer than the top of Hikurangi in the Ruahine Range—viz., *Celmisia incana, Pentachondra pumila, Ourisia macrophylla, Dacrydium bidwillii, Podocarpus nivalis, Danthonia semiannularis* var. *alpina, Oreobolus pumilio, Carpha alpina, Gleichenia dicarpa* var. *alpina.*"

Te Aroha Mountain (3,128 ft.), which consists of volcanic rocks, and occurs in the southern portion of the Hauraki Division, though it is 193 ft. higher than Te Moehau, shows none of these plants. But it occupies a more sheltered position, and it has not the broad wind-swept summit of Te Moehau. Hence the forest extends to the very top, and there is no open ground suitable for the growth of small

* The genera are arranged according to the sequence in Cheeseman's "Manual of New Zealand Flora."
† Trans. N.Z. Inst., vol. xxi, 1888, p. 40.

mountain plants. In this connection it is worthy of note that Mr. Adams remarks that the botanical evidence "appears to prove that Moehau is the oldest land-formation on the Cape Colville Peninsula."*

Climate.

The climate of the Coromandel subdivision offers no marked divergence from that prevailing in similar forest-clad localities in the northern portion of the Auckland Land District. Since there is no meteorological station within the subdivision, actual statistics as to temperature, rainfall, &c., cannot be given. The rainfall may be approximately gauged from records taken at the nearest stations—namely, Auckland City, Turua, Waihi, and Katikati.

As will be seen by reference to Chapter IV, the area under review forms the northern portion of general meridional-trending peninsula, with an axial divide averaging 1,500 ft. in elevation. The meteorological stations, Waihi and Katikati, lie on the southern continuation of the peninsula, 44 miles and 55 miles respectively south of the latitude of Coromandel Township, and on the eastern side of the divide; Turua lies on the low ground of the mainland, 34 miles south of Coromandel and 8 miles to the west of of its peninsular divide. Auckland City, situated on the mainland in country of low elevation, lies 40 miles to the west of Coromandel, and on the opposite shore of the Hauraki Gulf.

Records quoted as taken at Waihi, Katikati, and Turua, are the results of observations extending over a period of six years, ending the 31st December, 1906. The returns for Auckland are averages for forty years. The tabulations show the mean rainfall in inches per month, and also the mean number of days on which rain fell in each month.

—	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Totals.
						Mean Rainfall in Inches.							
Waihi	6·24	4·65	6·42	5·70	7·48	7·38	8·84	7·73	8·11	7·87	4·39	5·47	80·28
Katikati	4·58	4·80	4·40	4·45	6·38	4·97	7·50	6·32	5·49	5·31	4·11	3·66	61·97
Turua	4·30	3·48	3·14	4·61	3·61	3·56	6·15	3·33	4·68	5·30	3·18	3·29	48·63
Auckland	2·69	3·50	2·34	3·15	4·21	4·79	4·86	4·22	3·39	3·34	3 23	2·64	42·36
						Mean Number of Days with Rain.							
Waihi	10	11	14	15	17	17	18	17	17	18	13½	13	180½
Katikati	13	11	11	14	15	16	18	16	18	17	15	12	176
Turua	11	9	9	13	14	14	15½	16	17	13	10½	13	155
Auckland	10	10	9	12	14	18	19	17	16	15	12	11	163

These figures show a considerable variation in the mean rainfall at the several stations, and this is probably referable to local configuration. The rainfall recorded at Turua, of all these meteorological stations, may be assumed to most nearly approximate that of Coromandel Township.

The winds from the east and north-east are those accompanied by the heavy rains. The winds from the westerly direction are accompanied by fine weather, while those from the south-east generally result in cold weather with at times heavy showers. The general humidity of the climate is also evidenced by heavy dews which fall between sunset and sunrise.

Snow seldom or never falls in the subdivision, excepting on the crest of the mountain divide in the vicinity of Te Moehau Mountain, where the elevation ranges from 2,500 ft. to 2,935 ft. Even in this particular locality only very light falls occur in the most severe winter seasons.

As regards temperature, no records have been taken, except at the major station at Auckland City. These returns for a period extending over forty years show that the mean annual temperature is 58·8° F., that the coldest month is July, mean temperature 52·1° F., and the hottest month January, mean temperature 67·1° F., hence there is a remarkably slight variation in the mean temperature of the hottest and coldest months. It is believed that the extremes at Coromandel are somewhat greater than those at Auckland City.

* Trans. N.Z. Inst., vol. xxi. 1888, p. 40.

Scenery.

The Hauraki Peninsula, and more particularly the northern portion of the Coromandel area, has long been noted for its scenic beauty. From consideration of latitude and general elevation, one does not here look for the grandeur of the scenery and the magnitude of the land-forms which characterize much of the South Island country. The scenery of the Coromandel subdivision, however, possesses a charm of its own in the wonderful blending of the seascape with mountain and forest. The view from any of the main vantage-points on a clear day is one not soon to be forgotten, and a brief description based upon notes taken on an ascent of Te Moehau Peak may be here submitted.

Te Moehau (2,935 ft.), the highest mountain in the area, lies in the northern prolongation, some sixteen miles, as the crow flies, from Coromandel, the main centre of population, and is not particularly easy of access, but the magnificent view obtained from its summit, if the weather-conditions are favourable, amply repays the climber. This view is probably unsurpassed for range and quality by that obtained from any other point within a similar distance of Auckland City. The whole of the broken eastern coast-line of the North Island, with its background of undulating and mountainous country extending from Whangarei Heads in the north to the shores of the Bay of Plenty in the south, is spread out before the gaze of the spectator. To the west Auckland City facing the waters of the Waitemata Harbour, and the numerous volcanic cones studding the isthmus upon which the city stands are plainly visible, with the upper reaches of the Manukau Harbour, a deep indentation of the western coast-line of the North Island, in the background. The numerous rock-girt islands of the Hauraki Gulf, more particularly those which skirt the coast-line of the Cape Colville Peninsula from Te Kouma Harbour to Cabbage Bay, are especially picturesque. These islands all rise to considerable elevations above the sea-level, and are in the main covered with vegetation. To the north of Cape Colville the Great and Little Barrier Islands, and to the east Cuvier, Mercury, and a few smaller islands alone break the broad expanse of the Pacific Ocean.

The view of the peninsula itself looking southward from Te Moehau Mountain reveals strikingly the general rugged and broken character of the land-mass from coast-line to coast-line and the small proportion that the patches of low-lying country bear to the total area. Hill rising beyond hill, and ridge beyond ridge, appear as far as the eye can see. The Castle Rock and some of the other landmarks of the main range are not conspicuous against this background of hills, but the Camelback, the flat-topped Table Mountain, and Mount Te Aroha stand out clearly. It is, however, the nearer view that gives much of the charm to the scene. The luxuriant forest vegetation, with its every shade of green relieved in summer by the scarlet blooms of the rata, and near the coast-line by the brilliant flowers of the pohutukawa, clothes ridge and valley alike down to the very water's edge. Bays and harbours, affording sheltered sheets of water, indent the rock-girt coast-line, while the lighter-green colour of the cultivated fields near their margins contrasts strongly with the more sombre tints of the forest. Away in the direction of the Kuaotunu Peninsula the long white shelly beaches of this exposed coast-line, broken here and there by rocky headlands jutting out into the ocean, are bright and conspicuous on a fine day.

Although Te Moehau commands by far the most extensive view of the northern peninsular heights, Te Ranga (Look-out Rock), Tokatea Hill, Kaipawa, Castle Rock, and Pukewhakataratara, major elevations on the main range and all easily accessible, are vantage-points which afford particularly charming views of the surrounding country.

A ride along one of the many bush roads or tracks reveals the great wealth of the flora. Where the heavier trees have escaped the onslaught of the timber-cutter and the ravages of the forest-fires, the gigantic kauri (the "monarch of the New Zealand forest"), the rimu, the totara, and the kahikatea, tower above a luxuriant vegetation. The stately nikau palm, the gorgeous tree-ferns, and the handsome creepers here lend a semi-tropical aspect to the forest.

The picturesque gorges, cascades, and waterfalls, and the many rushing streams traversing this densely forested country, are in the main revealed only to those who penetrate into the deeper recesses of the woodlands.

PLATE I.

Castle Rock, from the Waiau Valley.

[*Photo. by Mr. Alex. McKay, F.G.S.*

Castle Rock, from the South-west.

[*Photo. by Mr. Alex. McKay, F.G.S.*

Literature.

Since the date of the earliest gold-discoveries many reports and notices have appeared, dealing with the geology and the mining industry of the area included within the Coromandel subdivision. The following list of authors and their publications may be considered fairly complete :—

The abbreviations used are—

Q.J.G.S. : Quarterly Journal of Geological Society, London.

Trans. : Transactions of the New Zealand Institute.

Rep. G.S. : Reports of the Geological Survey of New Zealand.

A capital letter followed by a figure (thus : C.-3) refers to a New Zealand parliamentary paper.

1854. Heaphy, Charles : "The Coromandel Gold-diggings." Q.J.G.S., vol. x, p. 322.

This is a short contribution describing the methods used to recover the detrital gold and auriferous quartz from the creek-gravels, and indicates a course for future operations.

1855. Heaphy, Charles : "The Gold-bearing District of Coromandel Harbour." Q.J.G.S., vol. xi, p. 31.

This contribution gives an outline of the geology of the locality, with special reference to the auriferous occurrences.

1864. Hochstetter, Ferd. von : "The Geology of New Zealand, in Explanation of the Geological and Topographical Atlas of New Zealand." (Translated by Dr. C. F. Fischer, Auckland.)

Hochstetter, Ferd. von, and Petermann, A. : "The Geology of New Zealand."

Pp. 15 and 51 have reference to the gold found at Coromandel.

Hochstetter, Ferd. von : "Geologie von Neu-Seeland. Beiträge zur Geologie der Provinzen Auckland und Nelson." "Novara" Exp., Geolog. Theil, Erster Band, Erste Abtheilung.

1867. Hochstetter, Ferd. von : "New Zealand, its Physical Geography, Geology, and Natural History." (Stuttgart, J. G. Cotta.)

Pp. 94–98 give a short geological and historical account of the Coromandel Goldfield.

1869. Hector, James : "Mining in New Zealand." (Abstract of Lectures delivered at the Colonial Museum.) Trans., vol. ii, p. 361.

Pp. 367–68 have brief reference to mining at Coromandel.

1870. Hutton, F W. : "The Geology of Coromandel." Rep. G.S., 1870–71, pp. 2–5.

This is a short report on the general geology, and has references to the existing mining areas.

Hector, James : "The Geology of Cape Colville District." Rep. G.S., 1870–71.

Pp. 88–98 have reference to the geology of the Coromandel district and the earliest mining operations.

1881. Cox, S. H. : "North Island District, including Thames, Coromandel, Island of Kawau, and Drury Coalfields." Rep. G.S., 1881.

Pp. 40–41 refer to the rocks of Tokatea Hill, and small coal-seams in the vicinity of Cabbage Bay.

Cox, S. H. : "Notes on the Mineralogy of New Zealand," Trans., vol. xiv, pp. 418–50.

This report describes certain minerals occurring at Coromandel.

1882. Cox, S. H. : "Goldfields of Cape Colville Peninsula." Rep. G.S., pp. 4–51.

This report deals with the geology of the peninsula as a whole, excepting the Mercury Bay area.

Cox, S. H. : "Notes on the Mineralogy of New Zealand." Trans., vol. xv, p. 361.

Continuation of paper of 1881. This describes the non-metallic minerals and cites various occurrences in the Coromandel subdivision.

1883. Bramhall, H. : "The Mineral Resources of New Zealand." Trans. Liverpool Geol. Ass.

McKay, A. : "The Geology of Cabbage Bay District, Cape Colville Peninsula." Rep. G.S., 1885, p. 192.

This report has special reference to the coal-bearing rocks near Torehine.

1887. Pond, J. A.: "Minerals of Cape Colville Peninsula." C.-3, p. 56.

Contains references to minerals occurring in the Coromandel subdivision.

Galvin, P.: "Handbook of New Zealand Mines." (Preface by Hon. W. J. M. Larnach.)

This volume has references to mining on the Coromandel Goldfield, pp. 278, 291, 295–99.

Hutton, F. W.: "The Rocks of the Hauraki Goldfields." Aust. Ass. Adv. Science, vol. i, p. 245.

This contribution deals with the volcanic rocks in which the auriferous veins occur.

Skey, William and McKay, A.: "Gold: Its Formation in our Reefs; and Notes of some Newly Discovered Reactions." Aust. Ass. Adv. Science, vol i, p. 155.

1889. Hutton, F. W.: "The Eruptive Rocks of New Zealand." Journ. Royal Soc. of N.S.W., vol. xxiii, p. 102.

P. 128, hornblende porphyrite, p. 133, hornblende andesite, from Coromandel, are petrographically described.

1890. C.-3, p. 39.

This contains the first official reference to the Kuaotunu Goldfield.

Hector, James: "Minerals of New Zealand." Rep. G.S., 1892, p. 105.

This mentions many minerals from the Coromandel subdivision.

1893. Park, James: "Notes on the Geology of the Kuaotunu Goldfield." Trans., vol. xxvi, p. 360.

1894. Murray, R. A. F.: "Report on Deep Quartz Mining in New Zealand." C.-6.

Pp. 1–5 have reference to mining conditions at Coromandel.

1895. Cadell, H. M.: "Gold-mining in the Hauraki District, New Zealand." Trans. Fed. Inst. Min. Eng.

Extracts from this paper are published in C.-3, 1896, p. 81.

1897. Park, James: "The Geology and Veins of the Hauraki Goldfields, New Zealand, with Maps and Sections." Trans. N.Z. Inst. Min. Eng.

This concise report includes a description of the geology of the Coromandel subdivision, and makes special reference to the several mining centres.

McKay, A.: "Geology of the Cape Colville Peninsula, with Map." C.-3, 1897.

This report covers the geology of the whole peninsula, with lengthy extracts from former writers on special areas.

McKay, A.: "Thermal Springs and Sinter-deposits of Cape Colville Peninsula." C.-9, p. 71.

Contains many references to occurrences in the Coromandel subdivision.

Campbell, Joseph: "The Goldfields of the Hauraki Peninsula." Trans. Fed. Inst. Min. Eng., pp. 12, 462, 482.

Campbell, Joseph: "Volcanic Zone of the Hauraki Goldfields." Scottish Geol. Mag., p. 246.

Wauchope, J. A.: "The Goldfields of the Hauraki District." Trans. Fed. Inst. Min. Eng., vol. xiv, pp. 19, 45.

1898. Don, J. R.: "The Genesis of certain Auriferous Lodes." Trans. Am. Inst. Min. Eng., vol. xxvii.

Maclaren, J. M.: "The Occurrence of Gold in the Coromandel District." Trans., vol. xxxi, p. 492.

This contribution describes the occurrence of gold in a crystalline form from Tokatea Hill.

Maclaren, J. M.: "The Geology of Te Moehau." Trans., vol. xxxi, p. 494.

McLeod, W. A.: "Notes on a Hornblende Trachyte from Tawhetarangi." Trans., vol. xxxi, p. 490.

Wilson, Geo.: "On some Differences that distinguish the Goldfields of the Hauraki Mining District, New Zealand." N.Z. Inst. Min. Eng., vol. ii, p. 17.

1899. Maclaren, J. M.: "Castle Rock, Coromandel." Trans., vol. xxxii, p. 213.

This contribution describes the geological and topographical features of Castle Rock.

Park, J., and Rutley, F.: "Notes on the Rhyolites of the Hauraki Goldfields, New Zealand." Q.J.G.S., vol. iv, p. 449.

This contains a petrographical description of a rhyolite from Mercury Bay.

1900. Park, James: "Notes on the Geological Examination of the Hauraki Goldfields." *New Zealand Mines Record*, vol. iii, p. 376.

Maclaren, J. M.: "The Geology of the Coromandel Goldfield." C.-9, 1900.

This is a detailed geological report on the Coromandel Goldfield, with maps and sections.

1901. Mulgan, E. K.: "The Volcanic Grits and Ash-beds in the Waitemata Series." Trans., vol. xxxiv, p. 414.

This paper has an indirect bearing on the geology of the Coromandel subdivision, in that it suggests a Miocene age for the volcanic rocks of the Beeson's Island Series.

Allen, F. B.: "Tellurium in the Ores of the Hauraki Goldfields." *New Zealand Mines Record*, vol. iv, pp. 467–70.

Coromandel is reported as the locality of one of the occurrences.

1903. Park, J.: "On the Jurassic Age of the Maitai Series." Trans., vol. xxxvi, p. 443.

In reviewing certain areas of so-called Maitai rocks, the writer ascribes an age no greater than Juro-Triassic to the basement rocks of the Hauraki Peninsula.

1904. McKay, A.: "The Igneous Character of the Carboniferous Rocks of the Tokatea Goldfield, Cape Colville Peninsula." C.-3, pp. 6–9.

1905. McKay, A., and Sollas, W. J.: "Rocks of the Cape Colville Peninsula." 1905–6 (two volumes).

This is the most complete and voluminous report yet issued on the petrography of the whole peninsula. It also covers briefly the general geology of the area, and includes pertinent field-notes.

Marshall, P.: "The Geography of New Zealand." (Publishers, Whitcombe and Tombs, Wellington, N.Z.)

This volume contains brief reference to the physiographic features of the Cape Colville Peninsula.

1906. Galvin, P.: "The Mining Handbook of New Zealand."

Has reference to the Coromandel subdivision in several articles, pp. 4, 17, 39, and 52.

Park, J.: "A Text-book of Mining Geology." (Publishers, Macmillan and Co.)

In this volume many of the illustrative examples are drawn from vein-occurrences in the mining centres of the Hauraki goldfields.

Loughnan, R. A.: "The First Gold-discoveries in New Zealand." (Wellington, Government Printer.) Reprint from *New Zealand Mines Record*, vols. ix and x.

CHAPTER II.

GENERAL CULTURE.

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Towns and Settlements.

The earliest European settlements on the Cape Colville Peninsula depended for their existence upon the kauri-timber industry. The western side of the peninsula, with its shores washed by the sheltered waters of the Hauraki Gulf and Firth of Thames, possessed special advantages in this connection; the forests extended almost to the water's edge, and contained a plentiful supply of kauri; the various sheltered inlets rendered most of the forest easily accessible; the rising seaport town of Auckland, distant only some forty miles on the opposite shore of the gulf, afforded a ready market for the building-material. Coromandel, Cabbage Bay, and Manaia were among the earliest of the west-coast settlements within the boundaries of the subdivision. On the eastern side of the peninsula the kauri forests of Mercury Bay, Whangapoua, Kennedy's Bay, and Port Charles, also attracted attention at an early date, and settlements dependent on the timber industry sprang up in these localities.

On account of the limited area of country covered by kauri and other sawmilling timbers, only those settlements that had natural resources other than timber had any real permanence. It is to gold-mining and to agricultural and pastoral pursuits that almost all the present settlements owe their existence. The working of the remnants of the kauri forests, and the digging of kauri-gum, however, still afford the means of livelihood to a limited number of the population.

The township of *Coromandel* is named after a British man-of-war which, in 1820, put into the harbour for the purpose of obtaining spars (kauri) for the navy. Some considerable time after this date the low grounds of the valley became the scene of active sawmilling operations, and thus a European settlement came into existence. Coromandel, however, if dependent solely on its timber resources, would, like many another such sawmilling centre, have rapidly declined. Ring's discovery in 1852 of fragments of highly auriferous quartz and detrital gold in a creek-bed threw quite a new light on the future prospects of the district. There was an immediate influx of a class of pioneers very different from the bushmen—namely, the gold-diggers and those who invariably follow in their wake. Even at that early date the possibilities of Coromandel as a goldfield were hopefully discussed, and subsequent discoveries were sufficient to establish it as a permanent mining centre.

The present township is charmingly situated on the low grounds of the valley between the foothills of the range and a picturesque harbour. Its history, owing to its dependence mainly on auriferous veins of the bonanza type, records several mining excitements, and attendant periods of prosperity, followed by the inevitable periods of depression.

According to the census of 1906, Coromandel contained a population of 1,208, although only eight years previously, owing to the mining "boom" in progress at that time, the population totalled over three thousand.

Cabbage Bay, situated some nine miles in a straight line north of Coromandel, according to the census of 1906 had a population of 108. The settlement was formerly the scene of active sawmilling operations, but, as only remnants of these kauri forests now exist, agriculture, kauri-gum digging, and occasionally mining and gold-prospecting operations, give employment to its limited population.

Manaia is a settlement some five and a half miles, as the crow flies, to the south of Coromandel, situated on the low alluvial flat at the mouth of the Manaia Stream, which enters the harbour of the same name. The population at the present time consists almost entirely of Maoris, but was formerly supplemented by Europeans engaged in the gold-mining and kauri-timber industries. The Maoris now eke out an existence by the tilling of the soil and by fishing.

Whitianga, situated on the estuary of the same name opening into Mercury Bay, is a small but flourishing seaport with a population of 476, which owes its existence not to mining, but to the milling and exporting of kauri timber, and to agriculture. It also forms the port for the smaller settlements situated in the valleys of the streams which flow into the estuary.

Kuaotunu is a straggling settlement lying in the valley of the Kuaotunu Stream, on the northern side of the peninsula of the same name. It was formerly a flourishing mining camp, with a population of about 800, which has gradually decreased until by the census of 1906 it stood at 281. Mining, agriculture, and kauri-gum digging afford its inhabitants the means of livelihood.

Whangapoua (population 73), *Kennedy's Bay* (population 51), *Port Charles* (population 34), are all located in more or less sheltered coastal inlets, and the inhabitants are supported mainly by agricultural and pastoral pursuits, timber-cutting, kauri-gum digging, and flax-milling.

The population, exclusive of Maoris, of the Coromandel County, according to the census of 1906, was 2,841, and of this number some 2,620 resided within the area included in the Coromandel subdivision. The Maoris scattered through the small coastal settlements number in all some 695, a mere remnant of the several powerful tribes that once peopled this portion of the peninsula.

Means of Communication.

No factor is more important in the exploitation and development of a goldfield than adequate and ready means of communication. In this connection the Coromandel subdivision, owing to its peninsular form and its proximity to Auckland the provincial metropolis, is very favourably situated.

Harbours, &c.—The picturesque harbour which gives access to Coromandel, the principal settlement, is almost landlocked, and consequently well sheltered. The principal disadvantage is due to the continual deposit of fine rock débris from various streams, which is effecting a gradual silting-up along the inner part of its margin. The wharf accommodation, owing to this shallowness of the water, is available, even for light-draught vessels, only at favourable states of the tide. Small steamers, however, which are capable of making the trip in less than four hours, trade regularly between this port and Auckland.

Communication with the other settlements on inlets of the western coast-line—Cabbage Bay and Manaia—is subject to the same disadvantage, extensive mud-flats extending along the shore-line of their harbours at low tide. Small steamers furnish means of communication with Coromandel.

On the more exposed eastern coast-line of the peninsula, Port Charles, Kennedy's Bay, and Whangapoua afford some shelter for coastal shipping; but the latter is a bar-harbour, and is workable only in very favourable weather. Kuaotunu is bounded by an exposed beach, and the coastal steamers can be tendered by barges and surf-boats only at favourable opportunities. Whitianga is much more happily situated, since the deep estuary which enters Mercury Bay furnishes safe anchorage for even the large ocean-going barques which are engaged in the kauri-timber export trade.

Regularly trading coastal steamers connect Whitianga and, during favourable weather, the smaller coastal settlements further north with the Port of Auckland.

Roads and Tracks.—The main overland route is the coach-road of some thirty-five miles in length, which connects Coromandel Township with the Thames, a more populous mining centre, and the railway terminus of the southern portion of the peninsula. Leaving Coromandel, this well graded and metalled road, after traversing the low grounds of the Tiki and passing over the hilly country separating the Coromandel and Manaia Harbours, reaches the Maori settlement of Manaia. From the alluvial flats of this settlement the road passes across the hilly country between Manaia and Kirita Bay, attaining a maximum elevation of 680 ft., and striking again for the coast-line it passes beyond the boundary of the Coromandel subdivision.

Graded bridle-tracks, as indicated on the maps accompanying this bulletin, connect Cabbage

Bay, Waiaro, and other minor settlements of the north-western coast-line, with the Township of Coromandel. Between Waiaro and Port Jackson a partly formed track exists.

In regard to overland communication between the settlements of the eastern and western shores of the peninsula, the mountain divide, which preserves an average elevation of about 1,500 ft., has always constituted the main engineering difficulty. Added to this is the fact that stone suitable for roadmaking is, over certain areas, only obtainable at long intervals, owing to a very general alteration and decomposition of the volcanic rocks. Very fair roads and tracks, however, exist, and these are constantly in course of improvement or extension. The road between Coromandel and Whitianga has up to the present time been passable only for saddle-horses ; but the necessary improvements now in progress along the more elevated stretches will very shortly admit of wheeled traffic between these centres.

Other cross-country graded roads and tracks radiating from the main centre of population are the Coromandel–Kuaotunu Road *via* Whangapoua, the Coromandel–Whangapoua Road *via* the Tiki Hill, and the Coromandel – Kennedy Bay Road *via* Tokatea Saddle. The first two of these are at present adapted only for saddle-horse traffic ; but the last-named, although in part of high gradient, permits of vehicular conveyance. Graded tracks connect Cabbage Bay on the west coast with Waikawau and Port Charles on the east coast, while an old and partly overgrown foot-track exists between Waiaro and the latter locality.

The various settlements of the eastern coast-line are connected with one another in part by portions of the routes already mentioned, and in part by specially formed roads and tracks. A graded bridle-track extends from Port Charles almost to Port Jackson. Port Charles is connected with Waikawau, and Waikawau with Kennedy's Bay. An unformed bush track leads from Kennedy's Bay to Whangapoua, and this latter settlement is itself connected with the main Coromandel–Kuaotunu Road. A road constructed for wheeled traffic leads from Kuaotunu to Whitianga, and from Whitianga formed bridle-tracks extend southward and south-eastward to Gumtown and Tairua, settlements located beyond the limits of the Coromandel subdivision.

Numerous minor roads and tracks connect outlying and isolated mining claims with the principal routes already mentioned.

Coromandel Township has telegraphic or telephonic communication with Auckland and Thames, and with the settlements of Whitianga, Kuaotunu, Whangapoua, and Cabbage Bay, all within the subdivision.

History of Gold-mining in the Coromandel Subdivision.

The discovery of gold in Australia in 1851, by Hargreaves, reacted very sensibly on New Zealand, since scarcely had the latter colony overcome the difficulties attending the commencement of its colonisation when a great number of its pioneering population rushed away to the new El Dorado.

The discoverie in Australia had, however, to some extent a beneficial effect on New Zealand, in that they directed attention to the possible occurrence of gold in this colony. Prospecting in New Zealand was therefore commenced, and received an incentive owing to the formation in Auckland, in October, 1852, of a Reward Committee, which offered a £500 bonus to the discoverer of a payable goldfield in the northern province. Within a week the bonus was claimed by Mr. Charles Ring, then a sawmiller in the Coromandel Valley, and, prior to arriving in New Zealand, a gold-prospector in California. Ring announced that he had discovered a payable goldfield at Coromandel, and produced at the same time specimens of auriferous quartz and a certain amount of fine detrital gold, which he had obtained from the bed of the Whangarahi Creek near the base of Tokatea Hill. Thus is recorded, in October, 1852, the first authenticated gold-discovery in New Zealand.

Forthwith negotiations were opened with the Maori landowners to permit of gold-mining on the Hauraki Peninsula, and resulted in an agreement (dated the 30th November, 1852) that the area lying between Cape Colville and Kauaeranga (now Shortland, Thames) should be opened for mining for a term of three years. Under this agreement the Government pledged itself to pay per annum to the Maoris—for less than 500 men digging, £600 ; for 500 to 1,000 men digging, £900 ; for 1,000 to 1,500 men digging, £1,200 ; for 1,500 to 2,000 men digging, £1,500 ; and, in addition, 2s. for each miner's

PLATE II.

TOKATEA HILL, FROM THE SOUTH-EAST.

[Photo. by Mr. Alex. McKay, F.G.S.

EAST SLOPE OF TOKATEA HILL. KENNEDY'S BAY IN THE DISTANCE.

[Photo. by Mr. Alex. McKay, F.G.S.

Kuaotunu Valley, looking North-east from Try Fluke Battery.
[*Photo. by Mr. Alex. McKay, F.G.S.*

Kuaotunu Valley, showing Northern Termination of Bald Spur.
[*Photo. by Mr. Alex. McKay, F.G.S.*

license issued. To meet this and other expenses a tax of £1 10s. per month per man was imposed on the miners, with, however, exemption for the first two months.

Within one month from the date of this agreement, three thousand men were on the Coromandel field, and the hitherto quiet sawmilling settlement at once assumed all the characteristics of a newly established mining camp. It was discovered, however, even at that early stage of mining operations that the auriferous areas were not continuous throughout the field, and two separate camps were established. One of these was that of Coolahan's Diggings, on the site of the present upper township of Coromandel, the other that of the Waiau Diggings, on the banks of the Waiau Stream and its tributary the Matawai.

The results in each case were very disappointing, and of the three thousand miners who "rushed" the field, it is said that only fifty took out licenses at the expiration of their two months' exemption period, and even these could not afford to pay the heavy monthly tax. Failure to locate payable gold, combined with the unfriendly attitude of the Natives, caused a general exodus of the diggers, and within six months the whole enterprise died out. The total value of the gold obtained during this period was £1,200 (the largest nugget being a cobble of auriferous quartz measuring 1½ in. in diameter, and valued at £10 sterling).

The stipulated bonus was withheld from Ring, since the Auckland Reward Committee did not consider the future prospects of the field sufficiently good.

For several years further exploitation of the field was prevented by the unfriendly attitude of the Natives, but in October, 1861, a second "rush" set in, as the result of the discovery of a highly auriferous quartz vein in the Kapanga (Scotty's) area, and following this Coromandel was proclaimed a goldfield on the 28th June, 1862.

The Kapanga area then became the scene of great activity, and attention was also directed to the previously abandoned Waiau Diggings. The Tiki Creek, a tributary of the Waiau, yielded before the end of the same year (1862) alluvial gold valued at £200, but, although this was mostly derived from detrital vein-quartz, prospecting operations failed to reveal the veins themselves.

The outbreak of Native hostilities in the Waikato District, Auckland, in 1863, gave a temporary check to mining in the Coromandel field, nevertheless the month of July of this same year saw the Kapanga Mine proprietors crushing ore from the vein previously mentioned. Up to May, 1864, according to Sir James Hector, the Kapanga Mine "yielded 2,198 oz. of gold from 1,706 lb. of quartz, and the remaining 100 tons from which the stone was picked yielded 400 oz.: approximate total value, £7,143."* "Other batteries," it is stated, "obtained 1,120 oz. from 40 tons," but it is not indicated from whence this ore was derived.

Operations were vigorously prosecuted with more or less success until 1866, when the discoveries of quartz veins of phenomenal richness at the Thames, some thirty-five miles to the south, caused a "rush" which deprived Coromandel of the greater part of its mining population. At the latter centre the Kapanga Mine alone continued working during the early part of this period of great excitement in the southern area. In 1869–70 the mining industry in Coromandel received a fresh impetus owing to the discovery of a wonderfully rich quartz vein on the Tokatea Hill. From 1870 to 1878 the Tokatea Diggings were the scene of great activity; the Tokatea Company, operating on this vein and another vein, the 'Tribute leader," discovered some three years later, paid to the shareholders £63,625 in dividends without calling up any of its capital.

Meanwhile the introduction of English capital in 1871, for the further development of the Kapanga Mine which had paid large dividends to the original holders, gave greater permanence to the industry. Furthermore, a considerable stimulus was furnished in 1872 by the discovery of the famous Green Harp shoot of gold, in a vein occurring in one of the low hills (within the boundary of the present Hauraki Mine) skirting the north-eastern inner shore-line of the Coromandel Harbour. This in a very short space of time yielded gold to the value of over £40,000.

In respect to the few years immediately preceding 1885 there is nothing of note to record as regards new discoveries, and unfortunately only a gradually diminishing output in the case of the older

* Rep. G.S., vol. vi, 1871, p. 90.

claims. This year, however, saw a mild "rush" to the Tiki, as the result of the discovery by H. Blackmore of a rich ore-shoot in a vein occurring in the range beyond Tiki Hill saddle. Vigorous prospecting in this locality resulted only in the further discovery of several very rich but rather small "pockets" of bonanza ore, and the Tiki Hill camp had therefore a comparatively short life.

From the opening of the Coromandel field up to the year 1889, all the gold-discoveries of any importance in the area under review were confined to the watershed draining into the Coromandel Harbour, and that draining into Kennedy's Bay on the eastern and opposite side of the main divide. Furthermore, the pay-ore was confined to rich shoots somewhat limited in extent, occurring in veins of no great thickness.

In 1889, highly payable quartz veins were discovered at Kuaotunu, a locality distant some thirteen miles (direct line) from Coromandel. As these veins were of larger dimensions than those worked at Coromandel, and contained the gold more evenly disseminated throughout the ore, it was hoped that a more permanent field had been located, and the discovery was hailed with considerable satisfaction.

The outcrop of the main reef in the prospector's claim, the Try Fluke, yielded ore which assayed as high as 15 oz. of gold per ton, and a "rush" immediately set in, with the inevitable pegging-out of all adjoining areas. The Try Fluke vein or branches of this vein carrying payable values, were soon traced into the Mariposa, Red Mercury, Great Mercury, and other claims, and it was therefore considered that here, at least, a permanent reefing-field existed. At a somewhat later date the quartz reefs of the Waitaia Mine, also located within the Kuaotunu Valley, were discovered. It was soon found, however that the gold existed in such a finely divided state in the Kuaotunu ore that the rather rough-and-ready amalgamation processes, which effected a fairly satisfactory extraction of the coarser gold in the Coromandel centre, were here altogether inadequate. Fine crushing and pan amalgamation was employed, with, however, only partial success until 1892, when the cyanide process was introduced, with an attendant reduction in the cost of treatment and a greatly enhanced extraction of gold and silver.

From the date of its discovery up to the 31st December, 1906, the mines of Kuaotunu outturned gold and silver to the value of £190,795. Consistent as was the ore, however, of the Try Fluke reef system in the upper levels, a marked falling-off in value characterized that found to exist at greater depths, and the gold-returns inevitably showed a marked decline.

The minor discoveries, in 1899, of gold-bearing veins at the Owera and at Lanigan's (Opitonui) are worthy of mention, as the localities lie midway between the old-established Coromandel centre and the newly discovered Kuaotunu area, and furthermore because these discoveries led to the extensive mining operations of the Kauri Freehold Gold Estates Comp ny in more recent years.

The main Coromandel centre, which for several years previous to 1894 had experienced a period of depression, was destined yet again to demonstrate in unmistakable manner that the possibilities of a goldfield of this character can never be gauged, nor can it ever be deemed, like many an old alluvial field, "worked out." The circumstances connected with the discovery of the bonanzas, which in 1894 brought the field again into prominence, are unique and deserving of record. These were located purely by accident in May, 1894, in a section of the mine owned and previously worked by the Coromandel Gold Company (registered in London). The Green Harp reef, already mentioned in connection with the rich ore-shoot discovered in 1872, occurred within the boundaries of the same claim, and together with other neighbouring and approximately parallel veins, constituted the principal ore-bodies operated on by the English company prior to this date.

A certain amount of prospecting-work was previous to 1894 carried on by the Coromandel Gold Company in the section of their mine which now comes under notice, but this was mainly directed under the misapprehension that veins, or, rather, auriferous veins, were only likely to occur striking approximately parallel to those already discovered. Upon the cessation of active operations by the proprietary company the claim was subdivided into blocks, and each of these, down to the datum plane of sea-level, was let on tribute. Messrs. Ross and Colthurst, who were working one of these blocks from a small shaft, located a shoot of gold in a vein of minor dimensions, and elected to drive an adit level a distance of some 300 ft. in order to mine their ore more expeditiously. The contours of the

country necessitated that the outer portion of this adit should be driven through the tribute block held by Legge and party, and in this block the wonderfully rich vein known as Legge's reef, or the No. 2 Hauraki reef, was intersected, striking almost transversely to the veins previously worked by the proprietary company. Legge and party, who previous to this discovery had worked for some eight months without return, had thus a rich bonanza vein discovered for them, and in the succeeding eight months of the term of their tribute, mined ore to the value of £11,928 14s.

The English proprietors immediately formed a new company, under the title of the "Hauraki Gold-mining Company (Limited)," with a capital of £40,000 (320,000 shares at 2s. 6d. each). The resumption of mining operations was attended with immediate and continued success; the bonanza of Legge's reef proved comparatively extensive, and, in addition to Legge's reef, many other valuable veins were located.

The returns from the phenomenally rich veins of the Hauraki Mine, in addition to the steadily increasing gold-output from the Waihi and other properties situated in the southern portion of the Hauraki Division, precipitated the "mining boom" of 1895 to 1899—one of the greatest periods of mining excitement that the Auckland goldfields have ever experienced. The area pegged out as mining claims was relatively enormous, and prospecting operations were consequently extended from the previously well-known centres to the back country. Colonial capital for mine-development was largely supplemented by English capital, and numerous companies were formed principally to exploit properties situated in the older-established centres. As is inevitable in all such periods of mining excitement, it cannot be affirmed that the expenditure of money was in all cases duly warranted, or that where expenditure was justified the mining operations were in every case intelligently directed.

The Hauraki Mine continued to hold its premier position throughout this period, outturning, from the 1st January, 1895, to 31st December, 1899, gold to the value of £239,915, and disbursing dividends to the shareholders of £176,000 on the capital of £40,000. The Bunker's Hill Mine, adjoining the Hauraki on its northern boundary, will also long be remembered for the frequent and considerable market fluctuations of its company's stock, although up to December, 1906, the mine only produced gold to the value of £17,017.

Among the English-owned mines of the Coromandel centre, in addition to the Hauraki, the Royal Oak – Tokatea Amalgamated, the Kapanga, Scotty's, Success, New Hauraki Gold Properties, Blagrove's Freehold, Kathleen Crown, Preece's Point, and Golden Pah are worthy of record principally on account of the expenditure incurred in development. Excepting the payment of one dividend amounting to £12,500 by the Royal Oak – Tokatea Company, none of these properties gave any returns to the shareholders for the capital expended, although some of them yielded gold, which partly covered the cost of development. The amount of gold obtained will be given later in dealing with the special mining areas.

At Kuaotunu further development-work was undertaken with the assistance of English capital. The Mariposa (originally the Try Fluke, old Mariposa, and certain adjoining areas), the Great Mercury, the Irene, and the Waitaia were the principal claims which received attention. Unfortunately no new finds of any importance eventuated, and work on the whole proved unremunerative. Probably the Waitaia claim was the only one of these that returned sufficient gold to cover the cost of development and mining.

In 1899 the Kauri Freehold Gold Estates (Limited) was registered in London, and acquired extensive areas of freehold land in the Coromandel subdivision. This was financially the strongest company that ever operated on the Coromandel Goldfield, and mining operations were centred chiefly on the comparatively large quartz veins which were known to exist in the Opitonui Valley within the main Whangapoua watershed. At the mine, shafts well equipped with pumping and winding machinery gave access to the underground workings on the veins. A modern forty-stamp mill with cyanide plant and all accessories was erected in a central position on the estate; the mines and battery were connected with each other and with the Port of Whangapoua by a substantial railway. The mining and milling operations, extending over a period of four years and a half, resulted in 53,355 tons of ore being raised and treated for a gross return of gold and silver valued at £63,723. In the end

the general verdict was that the veins were too low-grade to afford a margin of profit; the abandonment of the enterprise therefore followed, and with it the almost complete removal of the surface-plant equipment.

The mere tabulating of the names of the claims worked by local companies, syndicates, and private individuals during this period of activity would constitute a long list, and would serve no useful purpose. A few of these mines were remunerative, others gave small returns which partly covered the cost of mining operations, but the great majority, as might have been anticipated, yielded no return whatever. Of the remunerative mines, the Four-in-Hand, situated in the Waikoromiko district, must be pronounced the most important, and may further be counted a new discovery. The company owning the claim mined and crushed, during the years 1898 to 1906, 3,403 tons of ore for a return of £19,054 from which amount substantial dividends were paid on a small capitalisation.

The handsome returns from the Hauraki Mine largely compensated the English investors for the losses sustained on the other properties on the Coromandel Goldfield. The subsequent exhaustion, however, of the bonanza ore opened up in the veins of this mine, and the failure of the feeble attempts to locate other ore-shoots therein, resulted in a rapid decline in the monthly gold-output. This was the immediate forerunner of a general collapse of most of the subsidiary companies. The gradual withdrawal of the foreign capital reflected on the colonial mining-market, with the inevitable result that the period of remarkable mining activity and the attendant general prosperity on the Coromandel Goldfield came to an end. The reaction which followed the "boom" has been far-reaching, and for the past five years or more the mining industry, on which Coromandel and its environs so greatly depend, has continued in a languishing condition. To a development in the Bunker's Hill was due the mild excitement of 1902–3, when a rich ore-shoot was discovered by tributers in a portion of the mine considered heretofore thoroughly exploited; this resulted in a gold-return valued at £11,547 to the Bunker's Hill Company and its tributers, and about £4,500 to the Hauraki Freehold Company, the proprietors of the adjoining claim, into which a continuation of the shoot was traced.

English investors still continue to hold a few mining freeholds, none of which are now being worked, and one Crown leasehold, the Waitaia Mine at Kuaotunu, which has up to the present time yielded returns sufficient to cover working-expenses. The other important Crown mining leaseholds have been acquired by Auckland companies, and in Coromandel itself attention is now directed principally to the areas which have yielded the bulk of the gold of the past—namely, the Hauraki Mine and vicinity, Kapanga Mine and vicinity, Royal Oak Mine and vicinity.

Mineral-production.

The available data relative to the mining production in the early days of Coromandel, the oldest goldfield in New Zealand, are neither accurate nor easy to obtain. From the year 1886 the official returns issued by the Mines Department afford reliable information.

Mr. T. W. Rhodes, the prime mover in the inauguration of the Gold Jubilee Exhibition held in Coromandel in 1902, succeeded in arriving at an estimate of £1,437,302 as the value of the gold-production from the opening of the field up to the 30th September, 1898. These figures have been quoted in the *New Zealand Mines Record*,* and are probably as close an approximation as it is possible to obtain. In addition to this amount the official returns for the subsequent period brings the grand total to the 31st December, 1906, up to £1,743,790.

Having regard to the possible loss of old unofficial records, and also to the metal which may have been sold through other channels than the banks and not exported through the Customs, the figures quoted are much more likely to be under than over the true mark.

It is not very clear how much of the value above stated should be accredited to silver, which occurs throughout this mining-field alloyed with the gold in the form of electrum; probably £16,000 represents the minimum value of the silver produced from the opening of the field to the 31st December, 1906.

In addition to gold and silver, a few tons of picked complex sulphide ore containing lead, copper, and zinc have been exported, but the value is almost negligible.

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* Vol. ii, 1898, p. 128.

Industries other than Mining and Quarrying.

Agriculture.—Owing to the generally hilly character of the Cape Colville Peninsula the total area of the land suitable for farming is relatively small. Within the Coromandel subdivision the areas at present under cultivation are in general confined to the lower valleys of the various streams, more particularly to the flood-plains of streams entering the sea within sheltered inlets.

As the rocks within the various stream-valleys differ in nature, so also do the soils which have resulted from their denudation and decomposition. The greater fertility of the soil derived from certain of the andestic rocks as compared with that from the old sedimentary rocks is well exhibited in some of the hilly grassed clearings. Again, the contrast between the bare, barren, rhyolitic country lying to the east of the Whitianga Estuary, and the fertile plains of the andesitic area lying to the west is particularly well marked.

The most extensive tract of arable land within the subdivision is that just mentioned as lying on the western borders of the Whitianga Estuary, together with the long tongues extending up the valleys through which the Kaimarama River and its tributary the Mahakirau flows before discharging into this estuary.

This land is eminently suitable for dairying purposes, and it is a matter for surprise that no co-operation of interests has yet been brought about to establish a central butter-factory. The deviation and improvement of the Whitianga–Coromandel Road, which is at present in progress, will greatly assist in the further development of the Upper Mahakirau Valley, where a fair proportion, even of the hilly country, appears to be suitable for the depasturing of sheep and cattle.

At Coromandel the principal farming-lands fringe the harbour. Here a stretch of arable land, formed by the union of the flood-plains and fan deposits of the various streams, covers in the aggregate from two to three thousand acres and is subdivided into small holdings. Extending inland from the main area the flood-plains and lower slopes of the Waiau Valley are the portions which carry the most settlement.

Most of the smaller outlying settlements, now dependent principally on agriculture, have been mentioned in other sections of this report, but the possibilities of more speedy development in the case of certain localities may here be indicated.

The Maori settlements of Waiaro, Paparoa, Koputauaki, and Manaia, on the western coast-line, and Kennedy's Bay on the eastern coast-line, are all capable of much further development at a comparatively low cost. Areas of fertile alluvial flats and easy-sloping sidelings exist in the localities, on which tall manuka or light mixed bush is still standing. The value of this easily accessible timber for fuel would in part cover the cost of bringing these lands under cultivation. Again, certain tracts of land owned by private individuals or syndicates exist within the valleys of the various streams draining into Port Charles, Waikawau, and Whangapoua inlets on the east coast, and, though suitable for settlement, are at present lying idle. The clearing, grassing, and stocking of these areas would certainly be productive of payable results.

During the present temporary depression in the local mining industry more attention is being paid to the agricultural possibilities of the district generally, and settlement is being gradually extended from the low grounds up the lower slopes of the ranges. At Coromandel, the main centre, cattle-sale-yards have recently been established, and plans for furthering the dairying industry are at present under consideration.

All the fruits, vegetables, and cereals common to these latitudes are grown in favourable localities within the Cape Colville Peninsula, but the greater proportion of the land is more adapted for the depasturing of sheep and cattle.

According to the agricultural statistics of 1907, the Coromandel County, which is, however, slightly larger than the Coromandel subdivision of the present survey, contains 22,054 acres of improved land under crops and grasses, and 96,482 acres of tussock, Native grass, and unimproved pasture-land. The stock-list shows 6,806 cattle, 1,011 horses, 14,954 sheep, and 716 swine, and these numbers are undoubtedly capable of considerable expansion. In this connection the more energetic and successful of the farmers suggest that industrial experimenting should be undertaken more generally to ascertain

what varieties of grasses are especially adapted to the various classes of land, and what fertilisers give the best results.

Timber.—The timber industry has long been a very important one throughout the whole extent of the Hauraki Peninsula.

The kauri (*Agathis australis*) is by far the most abundant and most important timber for export and for local requirements. This is a tree which attains great dimensions, and grows in thick clumps at all elevations below 1,500 ft. It presents a long, straight, columnar barrel, normally from 4 ft. to 10 ft. in diameter, often without a branch for 60 ft. The timber is light in colour, of comparatively low specific gravity, and possesses considerable strength and durability. The sawn kauri is graded by the merchants into three classes, and their values for various constructional purposes may be gauged from the fact that the listed prices of these in Auckland City are—first-class, 17s. 6d.; medium, 14s. 6d.; and second-class, 9s. per hundred superficial feet.

The rimu or red-pine (*Dacrydium cupressinum*), kahikatea or white-pine (*Podocarpus dacrydioides*), and totara (*Podocarpus totara*) are marketable timbers, which, however, occur to a much lesser extent than the kauri within this area.

The value of mottled kauri, mottled rimu, and certain varieties of several of the other timbers in connection with cabinet-work and finer architectural work renders these worthy of special mention.

Puriri (*Vitex lucens*) is a tree which affords a valuable hardwood, used for all purposes requiring great strain and durability, such as railway-sleepers, ground-piles, &c. In furniture and cabinet making also, this wood is rapidly coming into favour, being equal in figure and general appearance to the finest walnut.

The pohutukawa (*Metrosideros tomentosa*) is especially sought after for use as knees and ribs in the construction of wooden vessels.

Rewarewa, or honeysuckle (*Knightia excelsa*), furnishes a beautifully variegated timber used for inlaying, cabinetmaking, &c.

Rata (*Metrosideros robusta*), manuka or tea-tree (*Leptospermum scoparium* and *L. ericoides*), are the hardwood timbers which occur in most abundance, and have the greatest value for fuel.

In the particular portion of the Hauraki area under review the fact that the peninsula is narrow has rendered the forests more accessible, and has resulted in their depletion earlier than in the more southern localities. The remains of the dams which were used in impounding water to drive the logs out of the creeks still exist near the heads of many of the watercourses, and are vanishing evidences of the substantial contributions of this portion of the area to the total timber-output of the peninsula.

Remnants of the kauri-forests are still being worked in the Cabbage Bay district and in the Te Pungapunga Valley, and timber to the extent of five or six million superficial feet is still standing at the headwaters of the Owera Creek.

At Whitianga a sawmill giving employment to some fifty men, and having an output of about 150,000 superficial feet of timber per week, is located on the northern shores of the Whitianga Estuary. The mill obtains its timber from the forests occurring within the valleys of the several streams which flow into the estuary from the country lying to the south. From the Port of Whitianga a considerable amount of timber "in the round" is also shipped away to the Auckland sawmills.

Kauri-gum.—Kauri-gum is the resinous exudation of the kauri-pine (*Agathis australis*). It occurs at shallow depths in the hillside soils and clays, or is found at somewhat greater depths in the swampy alluvial grounds, thus marking the actual positions or near vicinities of the great kauri forests of past centuries. This burial in the earth for extended periods has had the effect of clarifying the resin, and thereby considerably increasing its value. The gum is used principally for the manufacture of varnish.

The total amount of this product exported from the colony during the years 1853 to 1905, inclusive, was 226,165 tons, having a value of £12,920,531. This was practically all derived from the northern portion of the Auckland Land District, and, although the actual figures are not available, the Coromandel area may be considered to have contributed a fair proportion.

The occurrence of the kauri-gum in the Hauraki Peninsula has had more than a direct value. It has afforded many a mine-prospector in the backblocks a means of subsistence while pursuing his ordinary calling, and not a few of the gold-discoveries of the remoter localities are attributed to the individuals who are at once gold-seekers and gum-diggers.

Flax.—The New Zealand flax (*Phormium tenax*) occurs at various localities throughout the area under consideration, though never in great quantity. The flax grows most abundantly on the richer swamp lands, and here affords the fibre of best quality. That (*P. cookianum*) growing on the low wind-swept hills near Cape Colville is rather stunted and poor.

Three small flax-mills are operating in the district, all on the eastern side of the peninsula. These are situated at Waikawau, at Whangapoua, and at Cook's Bay near Whitianga. The raw material for the mills is drawn in the main from the low grounds of the various coastal inlets, and is boated from these points to the milling localities. Considering the high price of the fibre at the present time, it is probable that many of the low tracts of rich alluvial land occurring in some of the coastal inlets could be profitably employed in the cultivation of this plant.

Fishing.—Few portions of the New Zealand coastal seas offer better facilities for sea-fishing than does the Hauraki Gulf, the sheet of water separating the Cape Colville Peninsula from the mainland.

The schnapper (*Pagrus unicolor*) is by far the most abundant of the marketable fish of these waters, while among the others the flounder (*Rhombosolea monopus*) and the mullet (*Mugil perusii*) are perhaps the next in importance. The hapuka (*Oligorus gigas*), a valuable fish frequently found to weigh over 80 lb., also inhabits certain portions of the rocky sea-floor. On the more sheltered parts of the rocky coast the rock-oyster (*Ostrea glomerata*) is found in abundance, and as an edible shell-fish is highly valued.

Coromandel is the headquarters of a small fleet of fishing boats, which operate in the Hauraki Gulf near the western coast of the Cape Colville Peninsula. These boats transfer their fish to the coastal steamers trading to Auckland City, where a ready market is always available for the whole supply. The opposite shores of the peninsula are, in the main, exposed to the full force of the easterly winds ; but small boats carry on fishing within shelter of the inlets and the islands near the coast.

It is certain that the fishing industry within the Hauraki Gulf, and even along the outer coastline of the peninsula, will in course of time assume much greater proportions.

CHAPTER III.

OUTLINE OF THE GEOLOGY.

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Sequence of Formations.

The oldest rocks existent within the area of the Coromandel subdivision are sedimentaries, belonging to three distinct series, and volcanics interstratified with what is apparently the most ancient of these series.

Collectively these rocks constitute the folded and denuded stratified complex which has been frequently termed " the basement of the Cape Colville Peninsula."

The three series involved in this complex, placed in their probable order of succession, have been designated in this bulletin—

(*a.*) The Tokatea Hill Series ;
(*b.*) The Moehau Series ;
(*c.*) The Manaia Hill Series.

The Tokatea Hill Series consists of argillites, grauwackes, and interstratified tuffs and lavas of acidic character. The interbedded volcanics, and certain rocks which appear to represent an admixture of the finer-grained pyroclastics with the ordinary sediments, constitute a very large part of the series, and markedly characterize it throughout the whole subdivision.

The Moehau Series consists of a great thickness of thin-bedded argillites and grauwackes, which present considerable uniformity of character wherever they occur, and show no trace of contemporaneous volcanic rocks.

The age of the Tokatea Hill Series or of the Moehau Series is unknown, owing to the absence of palæontological data. Both are certainly Pre-Jurassic, since they are overlain unconformably by the rocks of the Manaia Hill Series, which contain Jurassic fossils. The relative position in the sequence of the Tokatea Hill Series and the Moehau Series is by no means evident in the area under review, since they have never been recognised as occurring in actual juxtaposition. The separation by the writers is based altogether on the lithological characteristics, which imply the deposition of the two series under very different conditions. The superposition, in the sequence, of the Moehau Series on the Tokatea Hill Series has been claimed by McKay,* who is the only previous investigator to suggest a subdivision of the basement rocks of the peninsula. His conclusions are based mainly on conditions obtaining beyond this subdivision. In deference to these conclusions, and in the absence of any evidence to the contrary, the writers, while assigning no definite age to the Pre-Jurassic rocks, have tentatively assumed that of the two the Tokatea Hill Series is the older.

The Manaia Hill Series consists of conglomerates, grits, grauwackes, and argillites, which have been derived from the denudation of a land-surface consisting largely of volcanic rocks, both of intermediate and of acidic character. Lithological and structural conditions alike imply the unconformable superposition of the rocks of this series on those of the Tokatea Hill and Moehau Series. The Manaia Hill rocks have, on palæontological evidence, been assigned by the writers to the Jurassic period.

Associated with the Tokatea Hill strata, intrusive igneous rocks abound ; with the Moehau strata such intrusives are of common occurrence, especially in certain localities ; in the Manaia Hill strata they occur very infrequently. In character these intrusives are intermediate or semi-basic, and occa-

* McKay : " Rocks of the Cape Colville Peninsula," vol. i, 1905, p. 34.

ERRATA.

In the table of formations facing page 22, under heading "McKay, 1905," transpose the subheadings "Middle and Upper Beds" and "Lower or Coal-bearing"; and after the word "Coal-bearing," insert the word "Series."

On page 39, paragraph 3, transpose the words "and none of" in line 13 and the words "rendered the" in line 14.

Cox, 1882.	Park, 1897.	Maclaren, 1900.	McKay, 1905.	Classification in this Bulletin.
Lower Carboniferous and Upper Devonian— Slates, sandstones, and felsites.	Palæozoic (Probably Devonian)*— Slaty shales and grauwackes (gold-bearing).	Carboniferous (Maitai Slates of Hochstetter)— Slaty shales, grauwackes, sandstones, crushed breccias, felsites, and felsitic tuffs.†	Te Anau Series (Upper Devonian)— Stratified beds of igneous material with associated eruptive and dyke rocks. Maitai Series (Carboniferous)— Sandstones, slaty shales and mudstones, with intruded dyke rocks. Wairoa Series (Triassic)— Sandstones and conglomerates formed of igneous rocks, and slates and sandstones.	Pre-Jurassic. Tokatea Hill Series— Argillites and grauwackes, with interstratified beds of igneous materials. Moehau Series— Argillites and grauwackes. Manaia Hill Series (Jurassic)— Argillites, grauwackes, grits and fine conglomerates.
Cretaceo-Tertiary— Coal-bearing series of Cabbage Bay.	Lower Eocene— Marine limestone, marly sandstones, and conglomerates with brown coal.	Lower Eocene— Clay marls, slate conglomerates, foraminiferal limestones, with small coal-seams.	Cretaceo-Tertiary. Middle and Upper Beds— Conglomerates, sandstones and shales with coal. Lower or Coal-bearing— Marly greensands with concretions, compact limestone and calcareous sandstones.	Torehine Series (Lower Eocene) (?)— (a.) Conglomerates, sandstones, and shales with coal-seams. (b.) Marly sandstones, calcareous sandstones, limestone.
Age Doubtful— Auriferous rocks of the Thames. Breccias and tuffs.	Upper Eocene— Andesitic lavas, tuffs, and agglomerates (gold-bearing).	Upper Eocene or Oligocene— Andesites (augite and hornblende), fresh and decomposed, fine-grained tuffs.	Thames-Tokatea Series (Eocene) (?)— Eruptive matter, mostly andesitic flow rocks, and breccias, &c., cut by dykes. Kapanga Series (Upper Eocene)— Same as above.	Tertiary Volcanic Rocks of the "First Period" (Upper Eocene) (?)— Acidic: Rhyolitic tuffs. Semi-basic: Andesitic and dacitic tuffs, breccias, and lava-flows.
Lower Miocene— Trachytic breccias.	Miocene— Andesitic breccias and tuffs.	Miocene— Trachytic and andesitic agglomerates, breccias, and dykes.	Beeson's Island Series (Miocene)— Eruptive matter wholly andesitic or dacitic; stratified tuff beds with coal.	Tertiary Volcanic Rocks of the "Second Period" or Beeson's Island Series (Miocene)— Semi-basic: Andesitic and dacitic tuffs, breccias, and lava-flows.
Pliocene— Rhyolite formation.	Pliocene— Rhyolitic lavas and tuffs.	[These acidic rocks do not occur in the area mapped by this writer.]	Pliocene. Older Rhyolites (Whitianga Beds)— Breccia agglomerates mostly of acid rocks, pumiceous sands, &c., with beds of lignite. Middle Rhyolites— Massive flow and intrusive rocks.	Tertiary Volcanic Rocks of the "Third Period" (Pliocene)— Acidic: Rhyolitic tuffs, breccias, lava-flows.
	Pleistocene— High-level gravel terraces. Recent— River-flats, swamps, and blown sands.	Pleistocene— River-terraces, lacustrine beds. Recent— Alluvial flats, harbour-muds, swamp-deposits.	Raised Beaches (Post-Pliocene)— Coarse beach-gravels. Alluvial— Coarse gravel, river-deposits and finer sediments.	Pre-Pleistocene, Pleistocene, and Recent— Unconsolidated or poorly consolidated débris. River-terraces, river-beds, sea-beaches, drifting sands, talus slopes.
				Intrusive Igneous Rocks of various Periods— Acidic: Rhyolite. Semi-basic: Diorite, porphyrite, andesite, dacite.

* In Trans. N.Z. Inst., vol. xxxvi., 1903, page 443, Prof. Park remarks: "Rocks belonging to the Jurassic system, in association with those of the Trias, form the greater portion of the Tararua, Ruahine, and Kaimanawa Mountains in the North Island; and we have no reason to assume a greater age for the slaty shales, sandstones, and grauwackes which form the floor of the Hauraki Peninsula."

† Moehau Series of Geological Survey Bulletin No. 4, does not occur in the area mapped by this writer.

sionally acidic. They are in greater part the analogues of Tertiary volcanic rocks; but there is evidence to suggest that some of the intrusions in the strata of the Tokatea Hill and Moehau Series are referable to a period prior to that during which the Manaia Hill sedimentaries were deposited.

Overlying the Jurassic and Pre-Jurassic rocks, and separated from them by a very marked unconformity, is a series of Lower Eocene(?) coal-bearing strata, which in this bulletin has been designated the Torehine Series. This series consists of conglomerates, sandstones, and shales, with coal-seams, marly and calcareous sandstones, and limestones, but is now represented only by isolated patches in a few separate localities.

A great accumulation of volcanic rocks has in Tertiary times been extruded upon the eroded and markedly irregular surface of the Jurassic and Pre-Jurassic sedimentary rocks, and upon the few remnants of the Lower Eocene(?) beds which overlie these older terranes. The Tertiary volcanic rocks are the products of three distinct periods of volcanic activity, and have in this bulletin been grouped under the following headings:—

(1.) Tertiary volcanic rocks of the First Period.
(2.) Tertiary volcanic rocks of the Second Period (Beeson's Island Series).
(3.) Tertiary volcanic rocks of the Third Period.

The rocks referred to the *First Period* consist of a great pile of tuffs, breccias, and lava-flows. Rocks of andesitic and dacitic character largely predominate here, but those of rhyolitic character are also represented.

The rocks of the *Second Period* consist of heavy accumulations of andesitic and dacitic tuffs, breccias, agglomerates, and lava-flows. These extrusives have, by all previous writers on the geology of the Cape Colville Peninsula, been designated the "Beeson's Island Series." Since the typical area lies within this subdivision, and the series named is so well established, it is in this bulletin used as an alternative in referring to the volcanics of the *Second Period*.

The rocks of the *Third Period* consist wholly of tuffs and lavas of rhyolitic character.

Associated with the volcanic rocks here grouped under different headings, are intrusive rocks of varying lithological character. They are the products of different periods, and are no doubt coeval with many of the intrusives existent in the old denuded sedimentary rocks.

Unconsolidated and loosely consolidated débris is confined chiefly to the floors and embayments of the stream-valleys, and to narrow strips along the coast-line. In age most of the débris now visible is *Pleistocene* or *Recent*, but some of that which mining operations have shown to exist at considerable depths is probably earlier than Pleistocene.

The tabulation facing page 22 sets forth the geological sequence as interpreted by the writers, and also the classifications adopted by previous investigators.

Geological History.

The argillites and grauwackes, which constitute the oldest rocks encountered in the Hauraki area, are the products of the denudation of a large land-mass. The position of the ancient land is perhaps impossible to determine, but from considerations both of palæontology and the depths of the ocean surrounding New Zealand, it is generally assumed that the sediments were transported from the eastward rather than from the westward. Deposition probably took place not far from land, on a gradually sinking sea-floor, and, judging by the presence of fairly coarse sandstones, in no great depth of water. The products are those characteristic of large rivers draining a continental area, rather than of small island streams.

The Tokatea Hill Series was laid down during a period marked by great volcanic activity, as evidenced by the numerous bands of acidic lavas and fine-grained tuffs interstratified with the ordinary sediments. Owing to the intimate mingling of the ordinary river detritus with these fine-grained tuffs, the resulting rocks show all gradations from argillites and grauwackes to the lighter-coloured highly tufaceous rocks.

The Moehau Series, which consists of a great thickness of thin-bedded argillites and grauwackes, is indicative of a long-continued period of deposition, and a period which, in marked contrast to the one already mentioned, was unbroken by any manifestations of vulcanism.

There appears to be no evidence as to whether any considerable earth-movement intervened between the period of formation of the Tokatea Hill and Moehau Series, but it is certain that altered conditions of sedimentation marked the deposition of the overlying Manaia Hill Series. The rocks of the last series, consisting of conglomerates, grits, grauwaekes, and shales, afford evidence of shallower-water conditions and contain undoubted Jurassic fossils.

Prior to Jurassic times, and subsequent to the deposition of the Moehau Series, volcanic activity must have been much in evidence in the vicinity of the area under consideration. This is deduced from the fact that the Jurassic sediments contain an abundance of small pebbles of flow andesites and flow rhyolites, as well as of porphyrite and other igneous rocks. The interstratified rhyolitic lavas forming part of the strata of the Tokatea Hill Series, might possibly be considered to have supplied the rhyolitic detritus forming part of the Manaia Hill Series. As to the locus, however, of the sheets of andesitic lavas requisite to supply such a large amount of detritus, one can only speculate, as no trace of such flow rocks has been detected *in situ*. Probably some of the numerous intrusions of porphyrite and diorite, associated with the strata of the Tokatea Hill and Moehau Series, represent the hypabyssal analogues of these Pre-Jurassic lava-flows. The very infrequent occurrence of intrusive igneous rocks in the Manaia Hill Series, and the less crystalline character of most of those that do occur—porphyrites and andesites (Tertiary)—afford considerable support to this conclusion.

Subsequent to the deposition of the Manaia Hill Series there ensued the great orogenic movements which have determined one of the most pronounced breaks in the whole geological history of New Zealand. The strata in the subdivision, consequent upon compressive forces acting in a general easterly and westerly direction, were folded and elevated. The flexures produced were so pronounced that in places the beds assumed a position of verticality.

A long period of subaerial denudation followed, during which the crests of the anticlines were removed and the land-forms characteristic of mature topography were further developed. The Coromandel Peninsula was probably, at this time, part of a large land-mass, the mountainous character of which may be deduced from the remnants of the surface preserved at the base of the Torehine Series.

The dawn of the Tertiary era saw this land-mass slowly submerged and receiving, in its river-valleys and estuaries, the fluviatile gravels and muds which have formed, on hardening, conglomerates and shales. The stage of maximum depression was marked by the deposition of limestone. The conglomerate, shales, marl, and limestone, which form what is termed in this bulletin the Torehine Series, are fossiliferous, and contain, in certain horizons, coal-seams marking pauses in the general positive movement of the shore-line.

Immediately subsequent to the deposition of the limestone, the upper member of the Torehine Series, there ensued a second period of great orogenic movement resulting in a further folding and elevation of the strata. The compressive forces producing this folding appear to have acted in approximately the same direction as those which gave origin to the late Jurassic folding. The fact that beds of the Torehine Series are found tilted at an angle of 45°, and that the isolated patches which are preserved, within comparatively short distances, range in elevation from sea-level to 1,200 ft., is sufficient evidence of great differential earth-movements.

Following, or in part contemporaneous with, the folding of the rocks, and to some extent the direct result of the orogenic movements, the stupendous volcanic energy which, with certain periods of intermission, has characterized the whole of the subsequent Tertiary era first manifested itself. Great piles of tuffs, breccias, and lavas were emitted from numerous volcanic vents, disposed in general north and south alignment along fissures or planes of weakness in the flexured sedimentary rocks. This great accumulation of material, which in places even now exceeds 2,000 ft. in thickness, has been grouped by the writers as the Tertiary volcanic rocks of the *First Period* of vulcanism. It is not, however, the product of a single continuous manifestation, but of several manifestations marked by pauses of greater or lesser duration, as evidenced by the intercalated seams of coaly material which occur in different localities.

A period of quiescence followed the last outburst of these early Tertiary eruptions, and the mountainous land-forms, which were largely the result of original volcanic accumulation, were considerably modified by the agencies of subaerial erosion. In certain localities these volcanics appear to

have been entirely removed from the surface of the old sedimentary or basement rocks before the deposition of the volcanic ejectamenta of the next period.

This extended period of quiescence came to an abrupt termination with the great volcanic outbursts of the *Second Period.* The principal foci of eruption during this period were confined to the sea-coast on both sides of the peninsula, and the predominating explosive and paroxysmal character of the eruptions was probably due in part to the access of sea-water to the fissures or vents. The products of the eruptions consist of andesitic tuffs, breccias, agglomerates, and lava-flows. The accumulation of much of the fragmental material under subaerial conditions is indicated by the inclusion of shattered remnants of forest vegetation, now carbonised or silicified. Further traces of this old land-vegetation are preserved as irregular coaly seams, which often mark the contact of these rocks with those of the earlier group. The closing manifestations of the vulcanism of this period appear to have been accompanied by the formation of numerous dykes intersecting the rocks of this and earlier periods.

The rocks here grouped as belonging to the *Second Period* have been regarded as of Miocene age, and the evidence adduced in support of this conclusion, as presented on a later page, appears to be fairly satisfactory.

The wonderful volcanic energy of the Tertiary era was, after another period of quiescence, yet again to display itself. Within the boundaries of the Coromandel subdivision, however, the products of this *Third Period* are confined to the extreme south-eastern portion of the area. They consist of rhyolitic rocks both fragmental and massive, and thus are sharply demarcated from the intermediate or semi-basic rocks which form the great bulk of the earlier Tertiary volcanic complex. Further than that the rhyolites of this period must be considered to overlie the Miocene andesites, there is no evidence afforded within the area examined which fixes the period of their eruption. They have hitherto always been referred to a Pliocene age, from structural considerations in areas further south than that considered in this bulletin.

The great deposits of siliceous sinter and chalcedonic quartz which characterize some localities; the deep-seated alterations of certain belts of the volcanics; the ore-deposits which these altered rocks frequently enclose: are all evidences of former periods of intense hydrothermal action. The structure of the volcanic pile, with its alternating beds of tuffs and lavas; the general permeability of the rock-material filling ancient foci of eruption; and fault fissures and the fissures of contraction due to the cooling and consolidation of the rocks: all combined to afford conditions highly favourable for the vigorous subterranean circulation of aqueous solutions. These manifestations of hydrothermal activity doubtless represented the "eruptive after-actions" which mark the dying stages of vulcanism. At these stages the heat still preserved in the rocks below the surface, and the gaseous emanations from deep-seated sources, supplied most of the motive power for the circulatory systems.

Certain considerable earth-movements have affected the area since the later eruptions of the *First Period.* One of the greatest of these movements is recorded in the existence of a nearly horizontal band of impure coal in the Kapanga Mine, Coromandel, at a depth of 700 ft. below sea-level, indicating a depression of not less than the magnitude specified. This carbonaceous band, which is now highly pyritised and silicified, is intercalated with fine tuffs or ash beds. In general it would appear as if movements of depression had affected the whole south-eastern portion of the area included within the Coromandel subdivision. More recent earth-movements, both of depression and elevation, took place in Quaternary times, resulting in the existing sunken valleys and raised beaches respectively.

At the close of the Pliocene period all volcanic activity ceased in this area, and the main constructive geological work since that time has been the filling-up of the bays and inlets by fluviatile agencies, a work which is still in progress.

General Structure of the Several Formations.

The strata of the Tokatea Hill, Moehau, and Manaia Hill Series have all been involved in the great orogenic movements of Late Jurassic or Post Jurassic times, and have in general a similar disposition. The folded complex appears to present the structure of an anticlinorium, with its principal axis in general alignment, though not in coincidence, with the trend of the main mountain divide. Owing probably to the effects of denudation, the youngest of these rocks—the Manaia Hill Series—are now

confined almost entirely to the lower flanks of this mountain-range. The folded strata, which are disposed at angles ranging in general from 40° to verticality, show no signs of metamorphism except in so far as they have been locally affected by the numerous diorite and porphyrite dykes which frequently intersect them. The strike of these rocks, with the exception of local irregularities, generally varies from a few degrees east to a few degrees west of the meridional line.

Orogenic movements must have affected the rocks of the Tokatea Hill and Moehau Series prior to the existence of the Manaia Hill Series ; the effects of these movements are now almost impossible to decipher, but they probably account for many of the variations from uniformity which exist in the present folded complex.

The rocks of the Torehine Series occur on both sides of the peninsula, but only as small isolated patches. They are found at very different elevations, overlying in marked unconformity a rugged and denuded surface of the older rocks. They are generally disposed at angles varying from 10° to 20° from the horizontal, but angles approaching 40° have been observed. The elevation of these strata above sea-level was therefore attended with considerable differential movements.

The Tertiary volcanic rocks of the *First Period* were apparently extruded after agencies of erosion had removed the greater part of the Torehine strata from off the older sedimentaries. They consist of irregularly stratified tuffs, breccias, and lava-flows ; the general mass of the rocks, especially in the lower horizon, is well consolidated. In vertical range they extend to elevations exceeding 2,000 ft. above sea-level, and in places pass below the datum-line of sea-level to an undetermined depth, exceeding 1,000 ft.

The rocks of the *Second Period*—Miocene(?)—form considerable coastal belts. Agglomerates, breccias, fine tuffs or ash-beds, and lava-flows, constitute the main mass of these volcanics. The degree of consolidation of the fragmental portion varies considerably, but in general is decidedly less than in the case of the pyroclastics of the *First Period.*

Intrusive rocks in the form of dykes and sills are irruptive into each of the series already described. They are principally diorites, porphyrites, and andesites, and probably range in age from Pre-Jurassic to Late Miocene.

Volcanics of the *Third Period* consist of fine pumiceous tuffs and flow rhyolites. The fragmental rocks are irregularly stratified and the inclination of the beds makes low angles with the horizon. The lavas appear to be younger and to have been erupted through these bedded tuffs.

The deposits of unconsolidated débris, consisting of gravels, sands, and muds, forming the river flood-plains and the fringing coastal plains, have a slight dip seaward, and present the usual false-bedded structures common to such material.

CHAPTER IV.

PHYSICAL GEOGRAPHY.

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General Physiographic Features.

The Cape Colville Peninsula, also known as the Coromandel or Hauraki Peninsula, constitutes the eastern and much the smaller of the two projecting land-masses which form the northern limits of the North Island of New Zealand.

This peninsula extends in a general north-south direction, and is separated from the larger physical feature, the North Auckland Peninsula, by the waters of the Hauraki Gulf. To the north and eastward of the coast-line of the Hauraki area only a few small islands break the broad expanse of the Pacific Ocean. The Great Barrier, the largest of these outlying islands, probably formed at one time a northward extension of the Cape Colville Peninsula, and was separated from it by the agencies of marine erosion.

The Coromandel subdivision of the present publication forms, as already indicated, the northern portion of the Cape Colville Peninsula.

The survey districts of Colville, Moehau, and Harataunga together constitute the northerly and narrower portion of this subdivision, the distance from coast to coast here averaging a little over six miles. A short distance south of the area included in these survey districts, the land immediately attains a width of some twenty miles, due to the subsidiary Kuaotunu Peninsula, projecting eastward from the Cape Colville Peninsula. With the exception of the contraction in width caused by the deep inlet Mercury Bay, which determines the peninsular character of the Kuaotunu area, this lateral dimension of twenty miles is preserved to and beyond the limits of the Coromandel subdivision.

The surface of that portion of the Cape Colville Peninsula which is within the Coromandel subdivision is in general of broken and rugged topography. The Pleistocene(?) subsidence of this diversified land-surface, with its numerous valleys, has afforded a relatively great length of shore-line, owing to the sea entering the irregularities of the land, and thus forming a typical rias coast.

From any position of vantage, either at a prominent point along the shore-line or at an elevated altitude in the interior, one can easily discern that the physical feature which dominates the Coromandel subdivision is the main divide—a range of low mountains averaging 1,500 ft. in height, and extending from the north of the Cape Colville Peninsula to and beyond the southern limits of the subdivision. Running from the main divide subsidiary ridges are conspicuous between the numerous streams which incise the country and flow to either side of the peninsula. Minor independent ridges and groups of hills occur in places between the main divide with its subsidiary ridges and the coast-line on either side. These outlying ridges and groups of hills are usually not far from the sea-border.

The mountainous country formed by the main divide and its subsidiary ridges, together with the minor independent ridges and groups of hills, forms by far the greatest part of the Coromandel

subdivision. The lowlands are inconspicuous: they are confined to flats along the sea-margin, forming incipient coastal belts, but little raised above high-tide level, and to narrow flood-plains extending from the lower part of the valleys of the main streams down to their mouths.

The main physiographic features of the Coromandel area may be considered under the headings of—

(1.) The main divide and its subsidiary ridges;
(2.) The outlying ridges and groups of hills;
(3.) The lowlands.

The Main Divide and its Subsidiary Ridges.

The main divide and its subsidiary ridges are together known as the Cape Colville Range. In the northern and narrower portion of the subdivision the crest of the range is almost equidistant from either shore; but in the southern and wider portion it lies nearer to the western than to the eastern coast. The general trend of the axial divide, considered from its northern extremity, is about south 50° east for a distance of about 10 miles, and thence south 18° east for a further distance of 18 miles, to the Waiau Saddle. From the Waiau Saddle to the boundary of the Coromandel subdivision ($3\frac{1}{2}$ miles) the trend, as will be mentioned later, departs considerably from the normal south-by-easterly direction.

For the sake of description these three portions marked by their different trends may be respectively designated (*a*) the Moehau Section, (*b*) the Cabbage Bay – Waiau Section, and (*c*) the Waiau–Mahakirau Section. Each will be separately discussed, together with the subsidiary ridges jutting from the several sections of the divide.

(*a.*) *The Moehau Section.*—The Moehau section of the Cape Colville Range constitutes both the most elevated portion in the subdivision, and the portion in which the old stratified rocks play the most prominent part in the structure. This section is known popularly as the Moehau Range. It is an area consisting essentially of highly folded argillites and grauwackes which are intruded and indurated by numerous dykes and sheets of igneous rocks, and consequently has offered considerable resistance to the agencies of subaerial erosion. The more easily weathered effusive volcanics form only the south-eastern portion of the Moehau section of the main divide.

The dominating and central feature in the section is Te Moehau Mountain, which rises 2,935 ft. above the sea, and presents from any point of view a decidedly massive appearance. At 25 chains south 75° east of the main crest of Te Moehau, and separated therefrom by a minor depression, stands a sharp conspicuous peak of only some 50 ft. lower elevation. This pinnacle owes its existence to the resistance to denudation given by the massive hornblende andesite, which occurs as an extrusion at this point.

From the wind-swept summit of Te Moehau, with its covering of subalpine vegetation, the elevation of the Cape Colville Range gradually decreases to a point some 35 chains in a north-westward direction, where a general altitude of 2,700 ft. is reached—a height which is preserved for a stretch of some one and a quarter miles. From here radiating spurs separated by deep valleys gradually fall to the level of the bold headlands of the northern coast-line.

Immediately to the south-east of the rocky peak of Te Moehau, the elevation of the water-parting decreases to about 2,500 ft. From this sudden descent the actual divide shows minor prominences and depressions until Trigonometrical Station H 6 is reached at an elevation of 2,054 ft. South from this trigonometrical station the ridge continues to fall for a distance of three miles: at first rather steeply then gradually until the boundary of the Moehau section is reached in the Cabbage Bay – Port Charles Saddle (500 ft.). This saddle, in which creeks flowing to the opposite sides of the peninsula have their sources, forms by far the lowest depression in the whole main range, and is crossed by one of the graded roads connecting settlements on each side of the divide.

The thickly wooded flanks of the Moehau section of the Cape Colville Range are deeply incised by numerous high-grade streams, with the consequent development of bold leading spurs descending from the axial divide to the actual sea-borders. Abrupt scarps, due in part to the existence of dyke rocks, are not uncommon. The steepest rock-faces are those overlooking the headwaters of the

streams draining into Stony Bay on the eastern coast-line. An initial fall of some 1,800 ft. in half a mile, may in places be here observed, with below this a more gradual descent of about 1,000 ft. to sea-level.

(*b.*) *The Cabbage Bay – Waiau Section.*—In the Cabbage Bay – Waiau section of the Cape Colville Range the older sedimentary rocks rarely reach to the crest of the axial divide, and it is to the overlying volcanic accumulations that the mountain-range mainly owes its height. The average strike of the strata in this section approximates fairly closely to the trend of the main range. This section of the main divide, in its trend from the low saddle (500 ft.) which separates it from the Moehau section, presents at first only minor elevations—from 800 ft. to 1,000 ft.—but further south a height of 1,500 ft. is attained, and preserved to the saddle some 60 chains north-north-east of Trigonometrical Station H1, where an old track, connecting Cabbage Bay with Kennedy's Bay, crosses. From this saddle the divide trends more towards the westward for a stretch of three miles, and presents fairly uniform elevations of 1,700 ft. to 1,800 ft. after the rather sharp initial rise from the saddle to Trigonometrical Station H1. Continuing southward the divide preserves a fairly straight south-23°-east course for eleven miles, to the Waiau Saddle.

The most conspicuous heights of the Cabbage Bay – Waiau section of the Cape Colville Range are, named in order from north to south, Te Ranga, or Look-out Rock, about 1,700 ft.; Tokatea Hill, 1,577 ft.; Trig. Hill UU, 1,852 ft.; Kaipawa, or Success Hill, 1,935 ft.; Castle Rock, 1,724 ft.; and Motutere, 1,763 ft.

The four first-named peaks call for little note physiographically, but in Castle Rock is presented the most salient feature of the whole landscape. As viewed from the Hauraki Gulf, it is a bold castellated crag having its longer axis coincident with the general trend of the axial divide. The mountain rises from a comparatively low saddle having an elevation of about 1,080 ft., at first with moderately steep slopes and finally with precipitous cliffs on three sides for the upper 400 ft. Castle Rock forms the most prominent outcrop of a great dyke of dacite which traverses the main divide in this vicinity. The mountain owes its local relief to the agencies of subaerial erosion, which have effected the removal of the easily weathered tuffs and lavas which the dyke has intruded.

Motutere (1,763 ft.) though slightly higher than Castle Rock is not nearly so conspicuous. The same dyke that forms Castle Rock forms Motutere, and gives rise to the very steep rugged country on both the eastern and western flanks of the main divide in this locality.

Saddles are not of common occurrence in the Cabbage Bay – Waiau section of the Cape Colville Range. The well-known Tokatea Saddle lies just to the south of the Tokatea Hill, where the Coromandel – Kennedy's Bay Road crosses at an elevation of about 1,200 ft. The Whangapoua Saddle, where the Coromandel–Kuaotunu Road crosses the main range, has an approximate elevation of 1,200 ft. The Opitonui Saddle (1,080 ft.), in the vicinity of Castle Rock, has already been mentioned, while further south, at the end of this section of the range, the Coromandel – Mercury Bay Road crosses the divide at the Waiau Saddle (1,155 ft.).

The character of the flanks of the range in the Cabbage Bay – Waiau section is fairly well indicated by the directions assumed by the various stream-valleys. These directions vary from an approximate parallelism with the main divide, through all intermediate angles to a transverse direction, and hence there arises a rather diversified topography. The spurs present fairly rounded outlines and, being in general capped with disintegrated rock-débris and vegetable mould, rarely show the rock *in situ*. The long, straight, outrunning ridges met with in Moehau Range with its more nearly transverse streams, do not often occur in the section under consideration.

(*c.*) *The Waiau–Mahakirau Section.*—This section of the main divide, which extends from the Waiau Saddle to the southern boundary of the Coromandel subdivision, is only three and a half miles in length, but is noteworthy as showing considerable departure from the usual trend of the range. From the saddle named, the divide bears south-west for about two miles and then regains and preserves its normal course of south-by-east to the boundary of the subdivision. No marked features characterize this stretch, which has a general elevation of 1,300 ft.

The Outlying Ridges and Groups of Hills.

It is difficult to precisely demarcate the ridges and spurs subsidiary to the main divide, and forming with it the Cape Colville Range, from the minor outlying ridges and spurs of hills nearly independent in origin and separate topographically from the main divide. For instance, sometimes ridges which are apparently quite distinct and individual are in reality merely separated by a low and inconsiderable saddle from a spur jutting from the main divide. Under the present heading will be considered only, (*a*) certain more or less definite ridges close to both coast-lines, which owe their origin to the accumulation of the volcanic ejectamenta of the Beeson's Island Series; (*b*) the ridge of hills on the Kuaotunu Peninsula; and (*c*) the hilly rhyolitic country east of Whitianga Estuary.

(*a*.) The explosive volcanic action of Miocene(?) times, along both coast-lines, has given rise to accumulations which now exist on the mainland, as comparatively low hills and ridges, and off the coast-line, as islands. On the western coast-line the low peninsular ridge and the hilly Beeson's Island, forming the north-western boundary of the Coromandel Harbour, come under this heading, and likewise the bare hilly country extending from the southern shores of Coromandel Harbour to Manaia Harbour. having a maximum elevation of 620 ft. From the south side of Manaia Harbour to Kirita Bay the same volcanic accumulation forms the elevated country which culminates in the sharp peak Pukewhakataratara at 1,293 ft. above sea-level. On the eastern side of the peninsula the accumulations of the Miocene eruptions, subsequently modified by subaerial erosion, have given rise to the hills, ridges, and spurs, showing little definite arrangement, which form the coastal belts between Port Charles and Whangapoua Harbour.

(*b*.) The Kuaotunu Peninsula has a general trend in a direction transverse to the central rib of the Cape Colville Range, and is dominated by a ridge which strikes away from the main divide at a point between Castle Rock and Motutere, and is in part to be considered with that feature rather than as independent therefrom. On the summit of this ridge, and distant about 70 chains from the main divide, rises Pinnacle Rock, which resembles in outline a huge shark-tooth, and is yet another portion of the intrusion to which Castle Rock owes its existence. Further eastward from Pinnacle Rock the dominant heights which occur at fairly regular intervals on the ridge are Hikurangi; Hukarahi, 935 ft; Waitaia Hill, 1,032 ft.; and Tahanga, 686 ft. The rocks forming this stretch of country are mostly volcanics of the Beeson's Island Series, and afford topographical outlines modified and rounded by subaerial erosion.

Independent of the main ridge of the Kuaotunu Peninsula are several isolated hills, the most conspicuous being Te Tutu (636 ft.), an ancient volcanic vent near the northern coast-line, and Mangatawhiri (985 ft.), a massive volcanic pile in a corresponding position on the southern coast-line. From Waitaia Hill (1,032 ft.) on the dividing ridge of the Kuaotunu Peninsula, a bold subsidiary ridge, known as Waitaia Ridge, extends in a direction north 32° west, terminating at the northern coast-line in Black Jack (702 ft.), a conspicuous hill which overlooks the lower township of Kuaotunu. This transverse ridge, which is the most conspicuous physical feature in the Kuaotunu Peninsula, consists of folded sedimentary rocks, and is probably the only existing remnant (on the mainland, at any rate) of an old line of elevation parallel to the main axis of the Cape Colville Peninsula.

(*c*.) The area lying to the east of Whitianga Estuary, and forming the south-eastern portion of the subdivision, consists of volcanic accumulations, subsequently modified by subaerial erosion. The hills, which consist of acidic tuffs and lavas, attain a maximum height of 670 ft., and present no definite arrangement.

The Lowlands.

As already remarked, the lowlands form a very small portion of the Coromandel subdivision, and occur as comparatively isolated areas. These comprise narrow flats close to the sea-margin, which represent incipient coastal plains formed by marine denudation and sedimentation, and the alluvial flood-plains of various streams which occur, almost entirely, within a short distance of the sea. They are most extensive when the flood-plains of two or more streams coalesce.

On the eastern coast-line the Whitianga flat, bordering the western side of the estuary of the same name, which debouches into Mercury Bay, together with the tongues extending up the valleys of

PLATE IV.

Waitaia Ridge and Black Jack Hill, from Materangi.

[*Photo. by Mr. Alex. McKay, F.G.S.*

Te Tutu Volcanic Neck, viewed from the Eastward.

[*Photo. by Mr. Alex. McKay, F.G.S.*

the Mahakirau and Kaimarama Rivers, forms by far the most extensive lowland area in the Coromandel subdivision. Further north, similar but smaller flats are found close to the mouths of the streams draining into Whangapoua Harbour, Kennedy's Bay, Waikawau, Port Charles, and Stony Bay. At Whangapoua Harbour, Omaro Spit, a long tongue of low-lying country, extends in an easterly direction from the hilly country of the Kuaotunu Peninsula, and determines the barrier between the open ocean and the shallow tidal mud-flats of the harbour. This spit has an area of some 1,093 acres, and is bordered near its outer margin by a long line of sand-dunes.

On the western coast-line the low grounds fringing the inner shore of the Coromandel Harbour, and extending back to the foothills of the ranges, probably form the largest single lowland area. The coalescence of the flood-plains and fans of many streams—chief among which are the Waiau and the Whangarahi, and their tributaries—contribute to the formation of this strip of country. The flats bordering the inner shores of the more contracted inlets, Manaia Harbour, Koputauaki Bay, Cabbage Bay, and Waiaro, and extending up the lower portions of the stream-valleys which debouch at these points, are the largest of the other lowland areas of this side of the peninsula.

Fringing the base of the Moehau Range on the western coast-line from the mouth of the Darkie Creek to Hope Creek is a long narrow area with a low inclination seaward. This gradually sloping land is formed by the overlapping fans of the various high-grade streams flowing off the mountain-range, and by the downward gravitation of talus from the higher country. Relatively recent elevation of the land has increased the area of low-lying country in this locality, the negative movement of the strand being shown by raised beaches in the neighbourhood of Ongahi Creek, Waiaro Creek, and elsewhere. The small bay of Port Jackson is bordered by a narrow lowland area, the product mainly of fluviatile and fluvio-marine deposits, with sand-dunes close to the shore-line. In addition to the sand-dunes mentioned as existing at Port Jackson and at Whangapoua, similar deposits also mark the exposed shore-line of Kuaotunu, Mahinapua, and Cook's Bay on the east coast.

Practically all the lowland areas so far described are either true flood-plains—the results of fluviatile deposition, or coastal belts—the products of fluvio-marine deposition—which have been recently uplifted above the sea. Flats of any extent due to marine denudation are rare; but very narrow shelves which border cliffs facing the open sea occur in several places. They are horizontal, or nearly so, and entirely submerged at high tide. Rocky shelves of such nature are common features of the coast of the peninsula. On the eastern coast-line may be mentioned those between Port Charles and Sandy Bay, and between Cape Colville and the Sugar Loaves; on the western coast-line may be noted those to the north and south of Goat Bay and at the headlands of Te Kouma and Manaia Harbours. These shelves are occasionally 100 ft. or more in width at low tides. The mud-flats occurring in the sheltered inlets of the coast-line testify to relatively large areas of marine deposition.

Features of the General Coast-line.

The present coast-line testifies to two distinct secular movements since the land-forms of the Coromandel subdivision assumed what is practically their present character. The numerous deep bays, the irregular promontories, the occasional sunken river-mouths, and the many outlying islands point to a former pronounced downward movement: while the raised gravel beaches and the mud-flats now partly elevated above high-tide level are indications of more recent upward movement.

The exposed eastern shores present, as might be expected, more broken and sinuous outlines than those of the opposite side of the peninsula. The principal inlets of this eastern coast-line—namely, Stony Bay, Port Charles, Kennedy's Bay, Whangapoua Harbour, and Mercury Bay, with the minor indentations of the latter—namely, Whitianga Harbour and Cook's Bay—have in other connections already been mentioned. The inner shores of all these inlets exhibit at low tide gradually shelving, spacious mud-flats, through which ramify the channels of the various streams. Fairly long stretches of sandy beach form the actual shore-line in certain localities. The most extensive of these are Matamataharakeke beach (1 mile), Kennedy's Bay beach ($1\frac{1}{4}$ miles), Te Pungapunga beach (1 mile), Whangapoua beach ($2\frac{1}{2}$ miles), Mahinapua beach (2 miles), Buffalo beach (2 miles), and Cook's beach ($1\frac{1}{4}$ miles), the two latter being within the main Mercury Bay inlet.

Rocky headlands, steep cliffs, narrow tidal ledges or shelves, outrunning reefs, minor indentations and caves, short boulder beaches, and outlying rocky islets, are all conspicuous features of the remaining portions of this eastern coast-line.

The coastal features of the country lying to the east of Whitianga Estuary which are due to marine denudation, are rather different from those of any other portion of the subdivision, owing to the difference in geological structure of the area. The almost horizontally bedded fine pumiceous tuffs give rise to conspicuous light-coloured vertical or undercut cliffs. Outlying stacks and projections here frequently present rather fantastic shapes. Some are sharp isolated masses while others, above the reach of the waves, are connected with the mainland. One huge tunnel, eroded through a headland a mile and a half north-west of Wigmore Creek on the eastern coast-line, measures 130 ft. in length by 50 ft. in width, and has a mean height of 30 ft. from its sandy floor to its well-arched roof. Narrow beaches in places border these cliffs, and are traversable at low states of the tide.

Shakespeare Cliff (elevation 288 ft.) is a bold precipitous headland lying just to the west of Cook's Bay, a sandy-beached minor indentation of Mercury Bay. These three names—Shakespeare Cliff, Cook's Bay, and Mercury Bay—bear reference to an interesting incident. Shakespeare Cliff is the spot where Captain Cook, in 1769, observed the transit of Mercury, and in Cook's Bay the navigator's vessel took up her anchorage.

At the extreme north-west of the Cape Colville Peninsula is the picturesque bay of Port Jackson, with its wide stretch of sand beach, and rugged promontories flanked by the rocky island-stacks to the east and west. Along the western coast-line, between Port Jackson and Cabbage Bay, rough rocky cliffs flanked by narrow rock-ledges, alternate with short, sandy beaches, or with much longer boulder-strewn beaches. Cabbage Bay is a spacious inlet with wide stretches of mud-flat visible at low water, and bordered in places by rugged cliffs. Southward from Cabbage Bay are the deep indentations of the coast-line known as Koputauaki and Kikowhakarere Bays, while still further south is the broad harbour of Coromandel. This harbour, measuring about three and a half miles by two miles, has two entering-passages, separated by Beeson's Island. The wild rocky coast from the main entrance of this harbour, southward to the limits of the subdivision, is deeply indented by Te Kouma and Manaia Harbours and the much smaller Kirita Bay. The two former inlets show in their inner reaches the usual extensive tidal mud-flats, incised by the winding channels of the various streams.

Islands.

The many islands which lie at no great distance off the shores of that part of the peninsula included within the Coromandel subdivision represent portions of the mountainous mainland, which have become separated therefrom in the many and varied tectonic changes which the area has undergone.

Of these numerous islands, only those lying off the western coast-line from Manaia Harbour to Cabbage Bay need be specially mentioned. The examination of the larger insular areas—namely, Great Barrier Island, Mercury Islands, and Cuvier Island—and the numerous islets lying to the north or west of the peninsula, has, as before stated, been deferred till another season.

Of the many islands off the western coast-line, Waihau or Beeson's Island, at the entrance of the Coromandel Harbour, is the largest. Geologically and topographically this island, volcanic in its origin, is representative of the whole group. It has, relatively to its area, considerable relief above the ocean level, and is girdled by a much-indented coast-line. Its tussocked or bushed slopes sometimes fall gradually to the shores of the small sandy bays, sometimes terminate in abrupt cliffs of greater or lesser heights. These cliffs in places pass almost vertically below the lowest tidal mark, whilst elsewhere they are skirted by heavy talus débris resting on a rocky marine shelf or a fringing shingle beach. Streamlets are of course very small, but water is also afforded by small springs which issue near the coast-line.

Streams.

The streams of the Coromandel subdivision exhibit normal conditions of drainage, and such as might be expected in a region of considerable relief free from complicating features of glaciation, &c. All the main streams rise near the mountain divide, and generally flow through small flats near

PLATE V.

SHAKESPEARE CLIFF, MERCURY BAY

[*Photo. by Mr. Alex. McKay, F.G.S.*

WHITIANGA ROCK, MERCURY BAY.

[*Photo. by Mr. Alex. McKay, F.G.S.*

PLATE VI.

THE COAST-LINE NORTH-EAST OF WAITAIA RIDGE.

[*Photo. by Mr. Alex. McKay, F.G.S.*

MATERANGI BLUFF, WITH BLACK JACK HILL IN THE DISTANCE

[*Photo. by Mr. Alex. McKay, F.G.S.*

their mouths. In the mountains their courses are often sinuous, with wild deep gorges, now broken by large or small waterfalls, again by rapids or cascades of considerable length. On the lowlands the streams meander, flowing with gentle current broken occasionally by inconsiderable rapids.

In the lowlands they are practically flowing at grade, and owing to the greater rapidity of fluviatile than of subaerial erosion this condition is usually continued backwards a considerable distance into the mountains. Slight departures from normal drainage conditions, depending on the nature of the underlying rocks of the country, will be exemplified later.

The generally elevated and rugged character of the district, together with its relatively small area, precludes the existence of large streams; few carry a sufficient volume of water to warrant their being described as rivers, and most of them, with propriety, are locally termed creeks.

For convenience of description the streams of the subdivision have been grouped as follows:—

(1.) Streams draining the northern portion of the subdivision;
(2.) Streams draining the southern portion of the subdivision, excepting those contained under heads (3) and (4);
(3.) Streams draining the Kuaotunu Peninsula;
(4.) Streams draining the area lying to the east of Whitianga Estuary.

(1.) *Streams draining the Northern Portion of the Subdivision.*—This area may be defined as all that north of a line drawn from Coromandel Harbour to Whangapoua Harbour.

Throughout this portion of the peninsula the mountain divide occupies a median position; this determines watercourses of approximately equal length to the eastern and western coast-lines. The streams flow naturally in directions more or less transverse to the trend of the main divide, but a convergence of streams to certain coastal inlets is more or less apparent. These latter phenomena are such as might be looked for in a drainage-system set up on a land-surface, whose physiographic features in early Tertiary times were the direct result of the effusion of volcanic materials from many vents. Modifications of pre-existing drainage appear to have been effected by the Tertiary eruptions of the "Second Period." It would seem that in certain localities, depressions were formed between the accumulations resulting from these coastal eruptions, and the flanks of the older land. In these depressions, which had for some distance directions more or less parallel to the main divide, drainage-channels were established which captured some of the older transverse streams of the higher country and received small tributaries from the coastal side. Examples of drainage of this kind are given by the Umangawha Creek, on the western side of the divide, flowing north into Cabbage Bay, and by the Wharcroa Stream on the eastern side, flowing south into Kennedy's Bay.

The watercourses of highest gradient naturally occur in the more elevated portion of this area—namely, the Moehau Range. Here the country consists of indurated argillites and grauwackes with intrusive dykes and sheets of igneous rocks, a structure which offers considerable resistance to fluviatile erosion, and gives rise to narrow gorges, waterfalls, deep rock-bound pools and rapids—features not uncommon, especially in the upper portion of the streams. Not infrequently, when a dyke occurs striking approximately parallel to the direction of the watercourse, the stream may be observed following the contact of the dyke and the intruded rock for a considerable distance, with a course not so sinuous as is ordinarily the case. South of the Moehau Range the effusive volcanic rocks overlie the old folded sedimentaries and take a greater part in the structure of the country. Wider-open valleys with gentler-sloping sidelings usually characterize stream incisions in these more easily eroded rocks. Intrusive rocks and beds of hard comparatively unaltered lavas and indurated breccias, however, are sufficiently resistant in places to give rise to more rugged features. More contracted valleys, with falls, pot-holes, gorges, &c., become noticeable where the streams have cut down to the level of the old indurated sedimentaries.

The streams flowing to both coast-lines are numerous, and only the most important need be mentioned. In the extreme north Bronlund Creek, draining the termination slope of Moehau Range, and the much smaller Huriwai Creek, skirting the western base of the low subsidiary ridge which ends at Cape Colville, flow into the sand-bordered bay of Port Jackson. The smaller creek forms swampy lagoons before breaking through the piled-up sand-dunes of this exposed locality. On the east coast Holland Creek is the largest of several small streams discharging on to the broken coast-

line north of Stony Bay. Into the latter bay the whole drainage of the rough eastern flanks of Te Moehau Mountain is delivered by converging streams which join together before reaching the lower ground skirting the shore-line. At the headwaters of these creeks small streamlets carrying the drainage of the crests and upper flanks of the mountains, tumble over the precipitous rock-faces which have been mentioned as occurring in this locality. Big Sandy Bay Creek, the Tangiaro and Kerr Creeks, entering the Port Charles Inlet, drain country consisting in the main of effusive easily eroded andesites, consequently their gradients are normal and their valleys more open than those of the Stony Bay creeks. Further south the Waikawau Stream, flowing in a general south-easterly direction, discharges on to the exposed sandy beach of Matamataharakeke. Up to a point some two miles from its mouth this stream is tidal, and at about 30 chains from the mouth it is joined on its right bank by its chief tributary, the Waikanae. These streams, except near their actual headwaters, present very easy bed-gradients. The hilly country of the main range and subsidiary ridges lying to the north, west, and south of Kennedy's Bay give rise to a number of relatively small streams which join the Harataunga before or after it reaches the estuary debouching into the north-west corner of the bay. The streams named in order from north to south are the Whareroa, the Mataiterangi with its tributary the Mangatu, the Wairakau, the Omoho, the Waverley, the Harataunga, the Waikoromiko, and the Kopurukaitai. The rocks of this drainage-area which is roughly semicircular in shape, consist partly of effusive volcanic rocks and partly of older sedimentaries with frequent igneous intrusions; the valley-forms are those which, as already described, characterize such areas.

Te Pungapunga Creek is a fairly large stream, draining the hilly andesitic country lying between Kennedy's Bay and Whangapoua Harbour. It flows in its middle and lower courses through a wide open valley, and discharges on to an exposed sandy beach.

The Waitekuri and Opitonui are the two most southerly streams of the eastern side of the narrow part of the peninsula under consideration; the valleys of both expose only andesitic rocks and exhibit the usual topographical characteristics. The waterfalls and gorges, consequent on the intrusion of the Castle Rock dyke, are prominent features in the headwater branches of the Opitonui Creek.

On the western side of the main divide the low flanks of the Moehau Range are scored by numerous small high-grade streamlets, and at intervals by somewhat larger creeks, which receive the drainage of the higher portions of the range. Among the larger streams may be mentioned Fantail, Darkie, Ohinewai, Ongahi, Hope, and Neilson Creeks, all debouching on the open coast-line. In their upper courses the bed-gradients are high, narrow gorges and waterfalls being of frequent occurrence. In their lower courses these streams meander through a narrow, fringing, alluvial area with a gentle seaward inclination; this area in the main owes its existence to the overlapping, widely spread fan débris from the several streams. The Waiaro, further south, is a stream rising on the saddle which indents the main range between the Waiaro and Port Charles Settlements. Its headwater branches incising indurated sedimentary rocks, broken through at various points by eruptives, present the usual topographical forms. About a mile and a half from the sea the flood-plains begin as a narrow wedge and gradually widen out to a width of about 40 chains at the shore-line. Low cut banks mark the limits of the present creek-bed winding through this lowland portion of the valley.

The small creeks flowing into the Ahirau Bay have their origin in the lowest saddle of the main divide, which lies between Trigonometrical Stations I (1,086 ft.) and C (803 ft.). After the usual steep descent from their headwaters these streams all flow through low-lying swamps to the marginal mud-flat of the upper portion of the bay.

The fairly large Umangawha Creek, flowing northward into Cabbage Bay, has already been mentioned in connection with its somewhat abnormal course. Grassed and bushed flood-plains form the base of the main valley from the Barney Creek junction to the shores of Cabbage Bay, a distance of about three miles. The headwaters of the main stream and its chief tributaries, Sutton, Barney, and White Star creeks, flowing from the eastward, cut through volcanic rocks overlying hard indurated sedimentaries. In its upper course Barney Creek plunges over precipitous faces of compacted rhyolite tuffs in a conspicuous fall 390 ft. in height. Branch Creek, the main westerly tributary, has cut its valley partly in the andesites of the coastal belt, partly in the Torehine beds and in the older sedimentaries.

On the coastal belt between Cabbage Bay and Koputauaki Bay, the largest streams are Anthony, Tawhetarangi, and Paparoa Creeks. Anthony Creek presents a unique feature in the drainage conditions of the Coromandel district, owing to the existence of limestone within its watershed. The stream disappears from the surface, and after following underground passages for some distance emerges at a lower level. The Whaiwango (Big Paul's) Creek and its main left-hand tributary, Little Paul's Creek, have their origin near the main divide. The upper portion of the valley is carved in the more easily eroded effusive volcanics, but the bed-rock of the middle course with its gorges and waterfalls consists of the resistant strata of the Tokatea Hill Series. The flood-plain forms the usual roughly triangular area, having as its base the shores of the Koputauaki Bay, into which inlet the stream debouches. Following the coast-line southward the small Kikowhakarere Stream, flowing into the bay of the same name, is encountered a mile and a half from Coromandel Township.

In the Coromandel Valley the Whangarahi and the Karaka, which junction on the alluvial plain shortly before reaching the inner shore of the Coromandel Harbour, are the chief drainage-channels. Tributary streams are numerous, many delivering into the main channels only after the low grounds skirting the foothills of the range are reached. Steep descents, as usual, mark the upper courses of all the streams. Tertiary volcanics and the old sedimentaries are the rocks traversed, and have their usual influence on the topographical forms and scenery of the valleys.

(2.) *Streams draining the Southern Portion of the Subdivision, except those contained under Heads* (3) *and* (4).—The increase in the width of the peninsula in this section, which lies south of the line drawn from Coromandel Harbour to Whangapoua Harbour, gives rise to an increased drainage-area and consequently to larger streams. The divide here does not occupy a median position, but lies nearer the western than the eastern coast-line, and this determines the greater drainage-area in the latter direction.

Practically the whole of the eastern watershed considered in this section is drained by the Mahakirau River. This stream, with its tributaries, collects the drainage of the eastern side of the whole stretch of the main mountain divide from a point half a mile north of Motutere to and beyond the southern boundary of the subdivision.

Since the Tertiary volcanics, massive and fragmental, which constitute the rocks of this watershed, have offered no great resistance to fluviatile erosion, the main valleys are generally of an open V shape, even far back in the mountains. A rapid descent continued for a short distance from the actual stream-origin (elevation about 1,200 ft.) near the crest of the main range, followed by a long, very gradual fall to the sea-level, is the profile which characterizes the stream-bed of the Mahakirau and that of its chief tributary, the Waitakatanga, even more than the many other streams of this subdivision. The lateral streams draining the flanks of the main river-valley, being naturally of high gradient throughout the greater part of their courses, show successions of waterfalls and rapids with small contracted gorges. From the foot of the initial steep descent of the Mahakirau, with its waterfalls and cascades, the stream flows with a sinuous course through a narrow valley over a boulder- and gravel-strewn bed of gradually diminishing gradient. Contracted gorges still occur at intervals as well as inconsiderable rapids followed by fairly deep pools. The further diminution of gradient is accompanied by low, bushed flood-plains, alternating along the stream's course, and rock *in situ* is observed only at intervals. These are the characteristics of the Mahakirau down to its junction with its main left-hand tributary, the Waitakatanga. From its junction with the Waitakatanga, a stream which shows conditions similar to the main drainage-channel, the valley opens and the alternating flood-plains increase in width. These conditions continue throughout a distance, measured in a straight line, of two miles and a quarter, to the confluence of the stream with the Kaimarama.

The Kaimarama River enters the subdivision flowing from a west-south-westerly direction, and meanders through the flood-plains of a wide open valley. It joins the Mahakirau with a volume of water approximately equal to that of the latter. From this junction it flows for a distance of three miles through fertile flats, finally debouching into an arm of the Whitianga Estuary.

The Waiau River, the Awakanae Creek, and the Mill Creek discharging into the Coromandel Harbour, the Manaia River flowing into the Manaia Harbour, and the Kirita Creek into Kirita Bay are the

principal streams draining the main western watershed of this section of the subdivision. Of these drainage-channels, those of the Waiau and the Manaia are much the largest, and are the only ones that call for further description.

The Waiau Stream rises in the Waiau Saddle, which has an elevation of 1,155 ft., and is situated 70 chains to the south of Motutere (1,763 ft.). This saddle is that in which the main branch of the Waitakatanga originates. The Waiau flows from this saddle in a general north-westerly direction: thus its course makes only a small angle with the trend of the axial divide, and its largest tributaries rising in the high country of the main range enter from the eastward. The main stream presents a fairly regular gradient, its gradual descent below the actual headwater slopes being interrupted only by a single fall of some 30 ft. in height. This feature, which is dignified by the name "Waiau Falls," is about a mile from the crest of the divide. The existence of indurated sedimentary rocks in the middle course of the stream gives rise here to contraction in the width of the valley, but at a distance of a mile in a straight line, or a mile and three-quarters following the bends, from the margin of Coromandel Harbour, the stream enters upon and meanders through the fertile alluvial plain known as Tiki Flat.

Those tributary streams of the Waiau entering from the eastward have their origin in the country lying between Castle Rock and Motutere, and fall abruptly over precipitous scarps, the walls of the Castle Rock dyke. One of these, Motutere Creek, in three closely consecutive steps descends 325 ft.* The Matawai Creek, one of the largest of the easterly tributaries, preserves a uniform gradient from its steep headwaters to within 45 chains of its junction with the Waiau. At this point a thick stratum of indurated quartzitic grauwacke gives rise to the Matawai Falls, which, in a distance of 5 chains, have a total drop of 80 ft. From the foot of these falls the stream-bed shows but slight inclination and meets the Waiau at grade.

The Tiki Creek, which in its upper portions flows in a general southerly direction, drains a large part of the flanks of the main range in the rear of the Coromandel Harbour. The stream presents normal characteristics, and joins the Waiau in the alluvial plain, at about a mile and three-quarters from the point where the main stream enters the tidal mud-flat of the inner border of the harbour.

Only the middle and lower courses of the main Manaia River lie within the limits of the subdivision. Its main tributaries, however, the Taurarahi and the Tupa, entering the main channel from the eastward, lie wholly within the area considered. The main stream has in general a north-westerly course, and where it crosses the southern boundary of the subdivision its valley is somewhat contracted owing to the existence at this point of resistant strata of the Tokatea Hill Series. A narrow gorge for a distance of 30 chains marks this portion of its course. From the headwaters of the main stream in the area south of that under consideration to the gorge portion mentioned, a quite normal gradient was found to obtain. Below the gorge the stream falls very gradually, and a mile down is joined on its northern side by the Taurarahi at an elevation of 20 ft. From this junction the stream incises its flood-plains, which from here gradually increase in width to the swampy borders of the Manaia Harbour, a mile and three-quarters distant. On its course through the flat the stream is joined by the Tupa, draining the country lying to the north-east. The Taurarahi and the Tupa have cut their valleys partly in volcanic and partly in sedimentary rocks, and present normal physiographic features.

(3.) *Streams draining the Kuaotunu Peninsula.*—This section includes that area north-east of a line drawn from the mouth of the Opitonui Stream to the entrance of the Whitianga Harbour.

The water-divide lies nearer the south-eastern than the north-western coast-line, so that the larger streams are those flowing in the latter direction. Of these, the Owera, Otanguru, Mapauriki, Kuaotunu, Otama, and Stewart may be mentioned. With the exception of the Kuaotunu Stream, their valleys are incised in Tertiary volcanics, and present the normal topographical features. Swampy alluvial flats mark their lower and sometimes their middle courses, and, as might be expected, these streams are frequently tidal for some distance from their mouths.

The Kuaotunu Stream has incised its valley principally in the old indurated sedimentary rocks, with the result that the valley-flanks are much steeper than those which incise the rapidly weathering

* The height of waterfalls and similar minor topographic features are barometric.

volcanics of the other creeks mentioned; particularly is this the case in the headwaters of the main right branch in the vicinity of the Waitaia Mine workings. Old stream-loops and small lagoons occur in the rear of the coastal sand-dunes, and narrow flood-plains extend for a relatively long distance up the valley.

Of the streams flowing to the southern shore of the Kuaotunu Peninsula those of the outer portion of the peninsula are very small and of high grade, flowing over rapids and falls which continue to the actual coast-line. Further south-westward somewhat larger streams effect the drainage of the area, the principal of these being the Kohurahorao, Waitaia, Woodcock, Akeake, Tarapataki, and Taputapu.

(4.) *Streams draining the Area lying to the East of Whitianga Estuary.*—This area, unlike any of those already considered, consists essentially of pumiceous tuffs and solid rhyolitic lavas, with the result that the drainage-channels exhibit special characteristics. The higher country is of the modified-plateau type, and often consists of hills showing little definite arrangement, consequently the trends of the water-divides are very irregular.

The typical profile of one of the larger streams of this section exhibits a steep descent for a very short distance from its source, followed by a stretch of low gradient terminated by a waterfall, and below this comparatively swampy ground through which the stream meanders to the coast-line.

A feature of these watercourses is the relatively great extent of the swamps. These are not confined to the low-lying flats, but occur in the watercourse-valleys of the higher country, extending almost to the water-divides. This is apparently due to the porosity of the pumiceous tuffs which take such a large share in the formation of the country. A great part of the rainfall is absorbed by these rocks and is transmitted very gradually to the watercourses, thus affording a fairly continuous supply of moisture to the valley-beds, and so favouring the growth of rank swamp vegetation. The absorption and transmission of surface waters by these porous rocks is also evidenced by the springs, which will be described later as occurring at the base of the slopes near the sea-borders.

The principal streams are Flax-mill Creek, which breaks through the sandhills of the first beach eastward of the mouth of Whitianga Estuary, Cook and Purangi Creeks flowing into Cook's Bay, Wigmore and Orua Creeks draining the extreme eastern part of the area. Of these, Purangi Creek is the largest, and all its branches debouch into a comparatively large estuary, a typical sunken river-valley some one and a half miles in length.

Springs.

The springs of the Coromandel subdivision, although inconspicuous natural features, are both of popular and scientific interest, and of some economic importance. They may, on a temperature classification, be considered under the headings of (*a*) hot springs and (*b*) cold springs.

Hot Springs.—The thermal springs in the district under review are phenomena of considerable interest, but the fact that such exist appears to be not very generally known, even in the neighbourhood of their occurrence.

These hot springs are found only in the vicinity of Mercury Bay, and are apparently confined to the area covered by the products of the latest period of volcanic activity, the rhyolitic rocks. Two are known to occur in the subdivision, one at Taputapu Creek, which debouches on to Buffalo Beach, Mercury Bay, and the other in the valley of Wigmore Creek, Purangi, in the extreme south-eastern portion of the subdivision.

At Orua or Hot Water Beach, on the eastern coast-line just beyond the southern boundary of the subdivision and two and a half miles south from Wigmore Spring, is a hot spring to which reference will be made for comparisons.

Taputapu Hot Spring: This spring is located in the actual bed of the Taputapu Creek, near the Buffalo Beach, and just a few feet on the seaward side of the footbridge where the main Whitianga–Kuaotunu Road crosses the creek. The hot water issues from the sandy creek-bed, which is unfortunately covered at this point by some 4½ ft. of water. Notwithstanding this depth of overlying creek-water, the temperature of the bottom silt is about 120° Fahr., that of the water midway between the bottom and the surface 100° Fahr., and at the surface 95° Fahr. Unfortunately, no sample of the

spring-water could be obtained for analysis, but it certainly appears to have a value for pathological purposes. Dr. Robert Bedford of Auckland, formerly in charge of the Mercury Bay Hospital, to whom the writers are indebted for the temperature-observations, writes, "The water in this pool had the property of alleviating fatigue in a remarkable degree; a bath in it was an excellent restorative after a long and tiring journey."

Considering that this spring is situated within 70 chains of the Mercury Bay Hospital, it is rather surprising that no attempt has been made to turn it to useful account. It is probable that the fissured rock from which the hot water emanates lies only at a small depth below the bed of the creek, otherwise the temperatures observed could not be maintained under such adverse conditions. The lower slope of the hills skirting the flat is distant about 17 chains to the northward of the spring, and shows rock *in situ*. In order to exploit the spring, pipe-sinking might first be attempted, in the hope that the hot water would rise above the level of the creek and thus be conveyed where required. Failing this method, the diversion of the creek might be practicable.

The Wigmore Spring: This spring occurs on the right bank of Wigmore Creek, some 40 chains from the mouth. The hot water at present issues from low swampy ground skirting the rhyolitic hills, but the actual site is rather difficult to locate owing to the dense scrubby vegetation which covers the area. It is said that strong puffs of steam emanating from the swamp are particularly noticeable in cold weather. Maori legends refer to the former existence, on the lowest portions of the hill-flank here, of a fine pool used for bathing purposes. This, it is said, was overwhelmed by a landslip, causing the waters to issue from their present more unfavourable position. No water was procurable for analysis.

Both of the springs described are undoubtedly to be referred to the rise of heated waters through deep-seated fissures in the volcanic rocks, as is also the Orua Hot Spring just outside the subdivision. The latter occurs on a sandy beach between the tide-marks, and storms at times lay bare the fissured rock.

The analysis of a sample of water taken from the Orua Spring is here submitted, as it may indicate the character of the waters of the springs within the Coromandel subdivision. (Results expressed in grains per gallon.)

Potassium-chloride	7·2
Sodium-chloride	200·8
Calcium-bicarbonate	22·5
Calcium-chloride	21·6
Magnesium-chloride	1·8
Silica	5·5
Total	259·4

Dr. Maclaurin remarks,—

"The absence of all but minute traces of sulphates shows that no appreciable amount of sea-water has gained access to the spring.

"The water belongs to the class of muriated saline waters found at Kawhia, Gisborne, &c.

"Most of the hot springs of this class in New Zealand contain iodine, but none could be detected in this water in the small amount available for the test."

Cold Springs are of infrequent occurrence in the subdivision, and afford only small volumes of water.

On Beeson's and certain other islands springs issue near the coast-line, and afford a constant supply of water even in the summer season, when the streams on the island become almost dry. At Purangi, on the eastern side of Whitianga Estuary, the springs of cold potable water, issuing in places from the pumiceous tuffs, are a great boon to the inhabitants, since rank swamp growth occurs in all the creeks and renders the water unsuitable for drinking purposes.

Water-power.

The comparatively limited area constituting the Coromandel subdivision, together with its salient physiographic features, precludes the existence of streams carrying, under normal conditions, any considerable volume of water.

The larger streams—namely, the Mahakirau, the Manaia, and the Waiau—however, would appear at first sight to warrant some consideration as sources of motive power, but further examination does not confirm such a conclusion. The profile of any one of these streams, considered from mouth to source, is that of a line having a very slight uniform rise for much the greater part of its length, followed by a sharply rising curve near its termination. The major volume of water is contributed to the trunk channel at relatively low elevations by numerous tributary streams; consequently, long before the necessary elevation for the intake of a water-race is attained, the volume of water in the main channel has become quite inconsiderable.

While no stream exists in the area which would afford adequate power for transmission to the mining centres, small high-grade streams are, as might be expected, of frequent occurrence in certain localities. The latter, however, are only of value as limited sources of power, if such power should be required in their immediate vicinities.

The abnormally high rainfall experienced during the summer season of 1906–7 and none of measurement of the volumes of water carried by the streams altogether unsatisfactory, rendered the the results obtained are herein submitted. A tabulation of volumes upon which any reliance could be placed is possible only as the result of several accurate measurements, extending over a lengthy time-interval. The only single measurement that can have much value is one made when the stream has fallen to almost its minimum volume. Such measurements were seldom or never possible during the extremely wet season mentioned.

CHAPTER V.

PRE-JURASSIC AND JURASSIC STRATIFIED ROCKS.

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Introduction.

Pre-Jurassic and Jurassic stratified rocks constitute the oldest visible terranes in the Coromandel subdivision. In the northern portion of the area they form the whole of the main mountain-range, while further south they constitute the basement or core of that range, or underlie the volcanic rocks at various depths. Considered collectively they have extent throughout the whole length of the peninsular areâ under review, but the exposures are not continuous at the surface owing to the heavy overmantle of volcanic rocks.

Structural and lithological considerations, which will be discussed later, have led to the subdivision of these stratified rocks into three series, designated in this report—

(*a.*) The Tokatea Hill Series } (Pre-Jurassic.)
(*b.*) The Moehau Series. }
(*c.*) The Manaia Hill Series. (Jurassic.)

The main orogenic movements which primarily determined the Pre-Tertiary land-forms of this area have involved the rocks of all these three series collectively, and it is therefore convenient to consider here the general disposition of the rock-complex as a whole.

The mapping of the strikes and dips of the strata throughout the whole area reveals great irregularities, even apart from the inevitable local deformations due to the intrusions of igneous rocks. The predominant strike of the strata throughout the whole area may be said to vary from 25° east to 25° west of the meridional line. The general trend of the peninsular mass and also of its axial divide, considered from the southern boundary of the Coromandel subdivision, is north-north-west to south-south-east for a distance of some twenty miles, and then, in the Moehau section, north-west to south-east for the remaining twelve miles. The strike of the rocks therefore presents a general parallelism to the trend of the greater part of the mountain-range, but crosses at a considerable angle the trend of the northern portion of this range. The beds appear to be disposed as an anticlinorium, the main structural axis of which lies in the main slightly to the eastward of the major portion, and altogether to the eastward of the minor Moehau portion of the main mountain-range. Within this anticlinorium small subsidiary folds appear to exist both to the eastward and westward of the mountain divide. In addition to the actual disposition of the beds as a whole, the distribution of the Jurassic sediments, the youngest of the folded complex, suggests general anticlinal arrangement. These sediments form a belt on the lower flanks of each side of the mountain divide. As in one or two cases they are found to approach, or attain to, the crest of the divide, it would appear that agencies of subaerial erosion prior to Tertiary times had effected an almost complete removal of these beds from the crown of the fold.

The Tokatea Hill Series.

GENERAL STATEMENT.

The rocks of the Tokatea Hill Series, which are probably the oldest in the district, consist of argillites, grauwackes, and interstratified beds of igneous material both fragmental and massive. In addition, rocks exist showing every phase of lithological gradation between the ordinary sedimentaries —argillites and grauwackes—and the interbedded pyroclastics. The rocks of this series present the same mineralogical characteristics wherever developed in the area, and are largely intruded by dykes of porphyrite, andesite, and rhyolite. Though highly folded, the bedded rocks show no evidence of dynamic metamorphism, and even in the vicinity of the igneous intrusions are only slightly and locally affected by contact metamorphism; they are, however, over considerable areas, altered and pyritised by the same agencies which have effected the propylitisation of considerable masses of the overlying andesitic rocks.

AGE AND CORRELATION.

The age of the Tokatea Hill Series is unknown owing to the absence of palæontological data. That the rocks are of Pre-Jurassic age is certain, as in the Manaia Valley they underlie unconformably grits and fine conglomerates which, on Manaia Hill some three miles away, have yielded Jurassic fossils. The Manaia Hill beds, moreover, contain pebbles of igneous rocks which have been derived in part from an area lithologically similar to the Tokatea Hill Series. Unconformity between the particular series under review and the Manaia Hill Series is very evident from a consideration of the sections exposed in the Tiki Creek with its tributary the Pukewhau, and in the Matawai Creek. Only a narrow bushed ridge separates the two valleys in question, which are approximately parallel to each other. The strike of the beds at similar elevations in each valley is transverse to the trend of the valleys, and yet the lithological character of the rocks in the two valleys is altogether different. Moreover, the Tokatea Hill Series in the Tiki Creek shows numerous dyke intrusions of porphyrite striking towards the Matawai Valley, but the rocks of the main Matawai Valley (Manaia Hill Series) show nowhere any sign of these intrusions.

The relationship between the Tokatea Hill Series and the Moehau Series is not nearly so evident, since the rocks do not occur in actual juxtaposition as do those of the two series already considered. Possibly some small area of the rocks of the Moehau Series occurs in the low grounds of the Waiau and Matawai Valleys, and has been included with the Manaia Hill Series, owing to the difficulty in the field of distinguishing the finer-grained sediments of one series from those of the other. If such is the case the same reasoning would apply as regards unconformity of the strata of the Tokatea Hill and Moehau Series. The separation of the Tokatea Hill and Moehau Series, however, is based on lithological rather than on structural considerations. The stratified beds of igneous material which everywhere characterize the Tokatea Hill Series are evidence of a period of sedimentation during which volcanic action made great display, and such evidence is conspicuously absent from the extensive exposures of the strata of the Moehau Series.

McKay* is the only previous writer who has suggested a subdivision of the rocks of the area under review into three distinct series. He assigns to the Tokatea Hill rocks a Devonian age, and considers them older than the Moehau Series of the present bulletin, which he refers to the Carboniferous period from lithological similarity to the rocks of the Maitai Valley, Nelson—a classical Carboniferous area. The present writers have no evidence to offer for or against these conclusions, but, while leaving the age an open question, they incline to the opinion that the Tokatea Hill Series is older than the Moehau Series.

GENERAL DISTRIBUTION.

The rocks of the Tokatea Hill Series have, in the subdivision, their greatest development on the western slopes of the main range, but are also found on its crest and on its eastern slopes.

On the western side of the range the most northerly outcrop of the rocks occurs as a small inlier surrounded by andesites, in the valley of the Whaiwango Creek (Big Paul's Creek) in the vicinity of its main junction.

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* Sollas and McKay: "Rocks of Cape Colville Peninsula," vol. i, 1905, p. 34.

South of the Tokatea Hill area, which will be later described, they are met with in Maddern Creek and in Courthouse Creek, in each case showing in the creek-bed for a distance of nearly a quarter of a mile immediately to the eastward of the Tokatea "Big Reef."

Further southward occurs the largest exposure of these rocks in the subdivision. This exposure has, on the Success Road, a width of about 35 chains and extends from 350 ft. to 650 ft. above sea-level. Passing southward from here this width increases. until in Cadman Creek the Tokatea rocks cover over a mile and a half; they also form in this locality the tongue extending out into the alluvial flat south of the Coromandel Township and known as "Green Hill." From Cadman Creek this exposure preserves a general south-south-easterly trend, to its point of termination just below the junction of the Matawai Creek with the Waiau River. The average width of this portion of the belt is about a mile, the stratified rocks extending from the edge of the alluvial plain or the very low andesitic foothills to elevations ranging from 650 ft. to 1,000 ft. on the western flanks of the main range. These rocks in Tiki Creek, which incises this belt, are as typical of the series as those of the Tokatea Hill area.

The Tokatea Hill Series is overlain by the Manaia Hill Series to the southward of Tiki Creek. On the map a line extending in a north-easterly direction from the Matawai Creek – Waiau River junction, and passing about 12 chains west of Pukewhau Saddle, marks approximately the contact of the two series, both being overlain at an elevation of 880 ft. by the Tertiary volcanics. At a distance of 35 chains east of Pukewhau Saddle along the Tiki–Opitonui Track, rocks characteristic of the Tokatea Hill Series are again conspicuous, forming an inlier surrounded partly by Jurassic strata (Manaia Hill Series) and partly by Tertiary volcanics.

In the Manaia River Valley occurs the most southerly development of these rocks in the subdivision. They extend from the fork of the main stream up the right branch for a distance of 33 chains, and up the left to and beyond the limits of the subdivision. This exposure as far as mapped is an inlier in Jurassic strata.

The area which includes the Tokatea Hill and Saddle—the typical locality—lies, in the main, on the eastern slopes of the mountain divide. The rocks are much altered, and the boundaries are often very poorly demarcated, the disintegrated shoadings of the numerous porphyrite dykes closely simulating the andesitic decomposition products. The boundary between the Tokatea Hill Series and the andesites on the western slopes of the Tokatea section of the main range, as shown on the map, is an arbitrary one, but probably follows closely the Tokatea "Big Reef," as this large quartz-body marks the contact in both Maddern and Courthouse Creeks immediately to the south. On the western slopes of the range to the south of the main Tokatea Road, at an elevation of 1,000 ft., the argillites occur in the workings of the Pigmy Mine. This is probably the lowest elevation of the main exposure in a southerly direction. The bushed country lying between the headwaters of the Waverley and Omoho Creeks probably conceals the northern boundary between this series and the Moehau Series. Extending down the eastern slopes of the main range, the Tokatea Hill Series forms the country incised by the Harataunga Stream and its tributary the Waverley, to a point near the junction of Waikoromiko Creek with the Harataunga Stream.

At Kuaotunu the altered light-grey spotted rock (page 45), exposed in the creek to the west of Hosie's Saddle, Waitaia Ridge, appears to be referable to an inlier of the Tokatea Hill Series in the grits and argillites of the Manaia Hill Series.

The general distribution of these rocks has been described at some length, as all the payably auriferous veins yet discovered in sedimentary rocks of the subdivision, with the exception of those in the Kuaotunu Goldfield, occur in the Tokatea Hill Series.

GENERAL STRUCTURE.

The general structure of this series has already been outlined in connection with the whole sedimentary complex. The prevailing strike is generally somewhat to the west of north, but is occasionally almost at right angles to this direction. The dip is, in the main, to the westward, and varies from 30° to verticality.

In the Tiki area certain sections disclose a gradually increasing inclination in passing eastward across the beds until the headwaters of the main branch of the Tiki Stream are reached, when the dip changes to the eastward; this may be the crest of the main anticline, but the easterly extension of the strata is concealed by overlying volcanics. In the Tokatea Hill area the disposition of the beds is

seldom apparent, but a westerly dip is probably preserved for some distance east of the mountain divide."

No faults of any magnitude have been detected in the area covered by these rocks, though minor fractures, with slickensided walls and bands of friction breccias, are all indicative of differential movement. An imperfect cleavage, which is generally parallel to the bedding planes, has been developed in some of the argillites, but more often they break with an irregular fracture.

An abundance of intrusive rocks, which will be described in another section of this chapter, characterizes every locality in which the rocks of the Tokatea Hill Series are developed.

PETROLOGY.

Introduction.—The rocks of the Tokatea Hill Series consist of dark-coloured argillites and grauwackes, with interstratified beds of volcanic material—both pyroclastics and lava-flows. The argillites and grauwackes represent the sediments derived from some ancient continental land-mass, while the igneous material is the product of contemporaneous volcanic activity. The igneous rocks and the rocks showing the many phases of lithological gradation between the pyroclastic igneous rocks and the ordinary sediments, afford considerable variety. The rocks of the series have been considered under the following headings :—

(*a.*) Argillites and grauwackes.
(*b.*) Acidic tuffs and tufaceous mudstones.
(*c.*) Quartz sericite rocks (altered rhyolites ?).
(*d.*) Contemporaneous rhyolites.

(*a.*) *Argillites and Grauwackes.*—The argillites and grauwackes generally occur as thin-bedded alternating strata of dark-grey or almost black colour with sometimes a greenish, bluish, or brownish tinge. The rocks weather to a yellowish-white thin soil. The decomposition clays frequently assume brilliant purple and red hues, due to percolation of iron-solutions from neighbouring andesitic areas, and are then with difficulty distinguished from the andesitic-decomposition products. Cleavage in these rocks is absent or is only incipiently developed, and true slates are therefore not represented in the area.

The grauwackes are mineralogically the same as the argillites, and differ from them only in the coarser nature of their clastic constituents. They consist, in the main, of fragmental quartz and feldspathic material with a minor amount of decomposing ferro-magnesian minerals, in a fine groundmass. In the vicinity of intrusions considerable induration, both of argillites and grauwackes, is noticeable, and the examination of some sections shows that minute shreds and scales of secondary biotite have been developed.

These rocks occur more or less in all the areas where the series is developed. In the Tiki Creek they both overlie and underlie the quartz sericite rocks and the tuffs. The dark drossy argillites met with in the vicinity of the Tokatea "Big Reef," in the No. 7 level of the Royal Oak Mine, should here be mentioned ; these are apparently higher in the sequence than the felsitic or rhyolitic tuffs to be later described, and probably owe their drossy, slickensided appearance to proximity to the "Big Reef."

(*b.*) *Acidic Tuffs and Tufaceous Mudstones.*—Under this heading have been grouped interesting and peculiar types of rocks, the true nature of which remained undetermined for many years. They occur in constant and intimate association with the quartz sericite rocks (altered rhyolites ?), wherever the latter are developed. They are doubtless the fragmental equivalents of these, or closely similar acidic-flow rocks, and the transition types which would result from a mingling of the fine tuffs with the ordinary argillaceous and arenaceous sediments. All these rocks, which are in general much lighter in colour than the argillites and grauwackes already described, are considerably altered and pyritised.

One of the most typical tuffs of the series occurs in Waverley Creek, on the eastern side of Tokatea Hill. Megascopically it is a compact, greyish, highly pyritised rock, with numerous small lighter-coloured spots. Under the microscope the fine matrix consists of angular and subangular fragmentary quartz with feldspathic material and sericite. In this matrix, decomposition products, including calcite and sericite, occur as areas having more or less rectilinear boundaries suggesting altered feldspars. Quartz is present both as irregular-shaped grains, and as roughly bipyramidal individuals ; cubes and segregations of pyrite are common. Similar rocks are met with in the Tokatea Mine workings, also at the Tiki and in the Manaia Valley.

Some of the most peculiar and frequently occurring rocks of the series are those which have in the petrographical monograph of Sollas and McKay* been termed respectively " spotted adinole," " spotted adinole or grauwacke," " spotted adinole or fine-grained grit," " grauwacke," " altered fragmental rock containing large fragments of a volcanic flow."

These rocks, which have generally a felsitic appearance, vary in colour from a leek-green to greenish-grey, grey, and bluish-black. They are frequently mottled with rounded spots or arborescent patches, usually of greenish tint and darker than the general mass of the rock. These spots are usually small, but occasionally exceed an inch or an inch and a half in diameter. The rocks are in the main very fine-grained and compact, breaking with a subconchoidal or splintery fracture, and showing sharp edges which at times exhibit faint translucence. Platy jointing is not uncommon, and the joints often include patches or films of bright pyrite, which mineral, as fine grains and aggregates, also occurs generally throughout the rock. A parallel banding is occasionally noticeable. Less frequently the rocks are softer and lighter-coloured, and present a somewhat steatitic appearance.

Under the microscope the matrix has a dusty granular or sometimes minutely crystalline appearance and frequently shows patchy extinction between crossed nicols. Scattered through this finer matrix is quartz as angular grains, splinters, and rarely rounded granules. Minute bipyramids of this mineral are also present. Plagioclase feldspar occurs as angular flakes, shreds, and rounded grains, the extinction angles, 15°/15°, indicating an acid type. Pseudomorphs of calcite and sericite after this mineral are not infrequent. Orthoclase has certainly been detected in the sections, but is considerably sericitised. Sericite, in part already mentioned in previous sentences, is, next to quartz, probably the most abundant mineral in these rocks, and with it is sometimes associated chlorite. A few worn flakes of muscovite, in addition to secondary muscovite, and ilmenite granules altering to leucoxene, have also been detected. Pyrite as cubes and grains, and as films lining fractures, is more or less conspicuous in all these rocks. The peculiar spots and rounded patches which sometimes simulate the andalusite growths in a spotted schist, are the result of secondary changes by which some new mineral has been sporadically developed throughout the matrix, but the mineral itself has not been determined. These spots are freer from granules than the general matrix of the rock. One of these rocks, the matrix of which includes small bipyramids of quartz, is of considerable interest as affording additional proofs of volcanic action contemporaneous with this period of sedimentation. Concerning these fragments Professor Sollas remarks: " Some (1) [are] fairly large, consisting of altered feldspar laths with trachytic habit in flow lines, spotted with patches of carbonates; (2) others [are] composed of large isolated grains of quartz and large sericite pseudomorphs after feldspar. The coarse fragmentary material (2) is opposed to the notion that this is a flow rock with included xenoliths, and leads to the conclusion that it is fragmental but largely composed of fragments of flow rocks."†

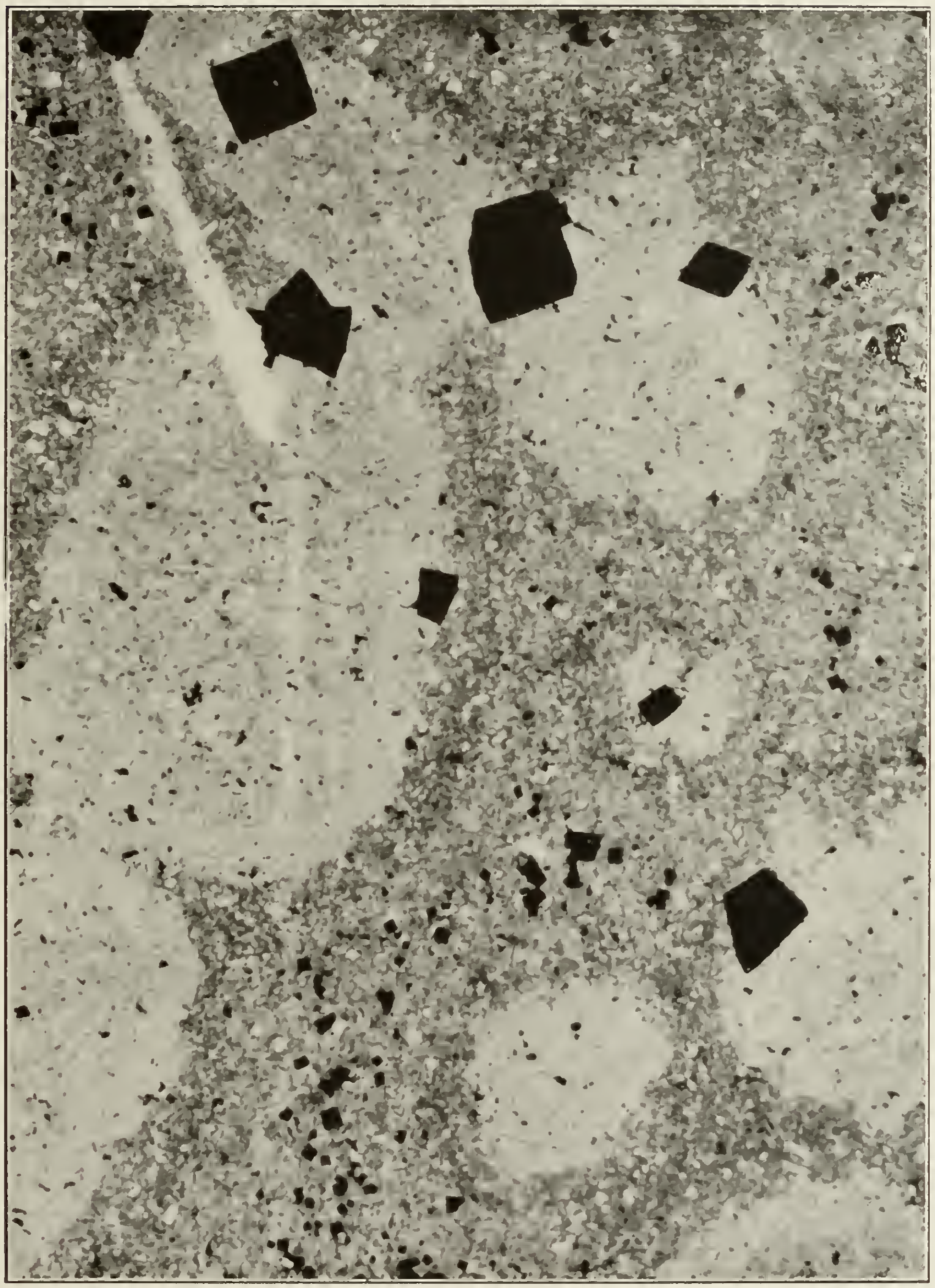
The analyses of four typical samples of these rocks are as follows :—

	1.	2.	3.	4.
Silica (SiO_2)	60·75	57·72	58·40	66·20
Alumina (Al_2O_3)	18·34	22·49	19·11	20·51
Ferric oxide (Fe_2O_3)	0·40	0·96	5·76	0·84
Ferrous oxide (FeO)	5·76	4·82	1·22	1·12
Manganous oxide (MnO)	0·42	0·31	0·29	..
Lime (CaO)	2·60	1·05	2·95	0·95
Magnesia (MgO)	2·03	2·34	2·84	0·72
Potassium-oxide (K_2O)	2·92	3·87	2·59	3·10
Sodium-oxide (Na_2O)	1·69	1·18	2·80	0·90
Titanium-oxide (TiO_2)	0·51	0·66	0·72	0·21
Carbonic anhydride (CO_2)	1·50	0·05	1·84	0·10
Water and organic matter	3·30	4·80	1·76	5·50
Totals	100·22	100·25	100·28	100·15

Locality.—No. 1, Tiki Creek; No. 2, Hauraki Associated Mine, Tokatea Hill; No. 3, Peveril Mine, south of Tokatea Saddle; No. 4, No. 3 level, Royal Oak Mine, Tokatea Hill.

* Sollas and McKay: " The Rocks of Cape Colville Peninsula," vol. i, 1905; vol. ii, 1906.
† *Loc. cit.*, vol. i, 1905, p. 186.

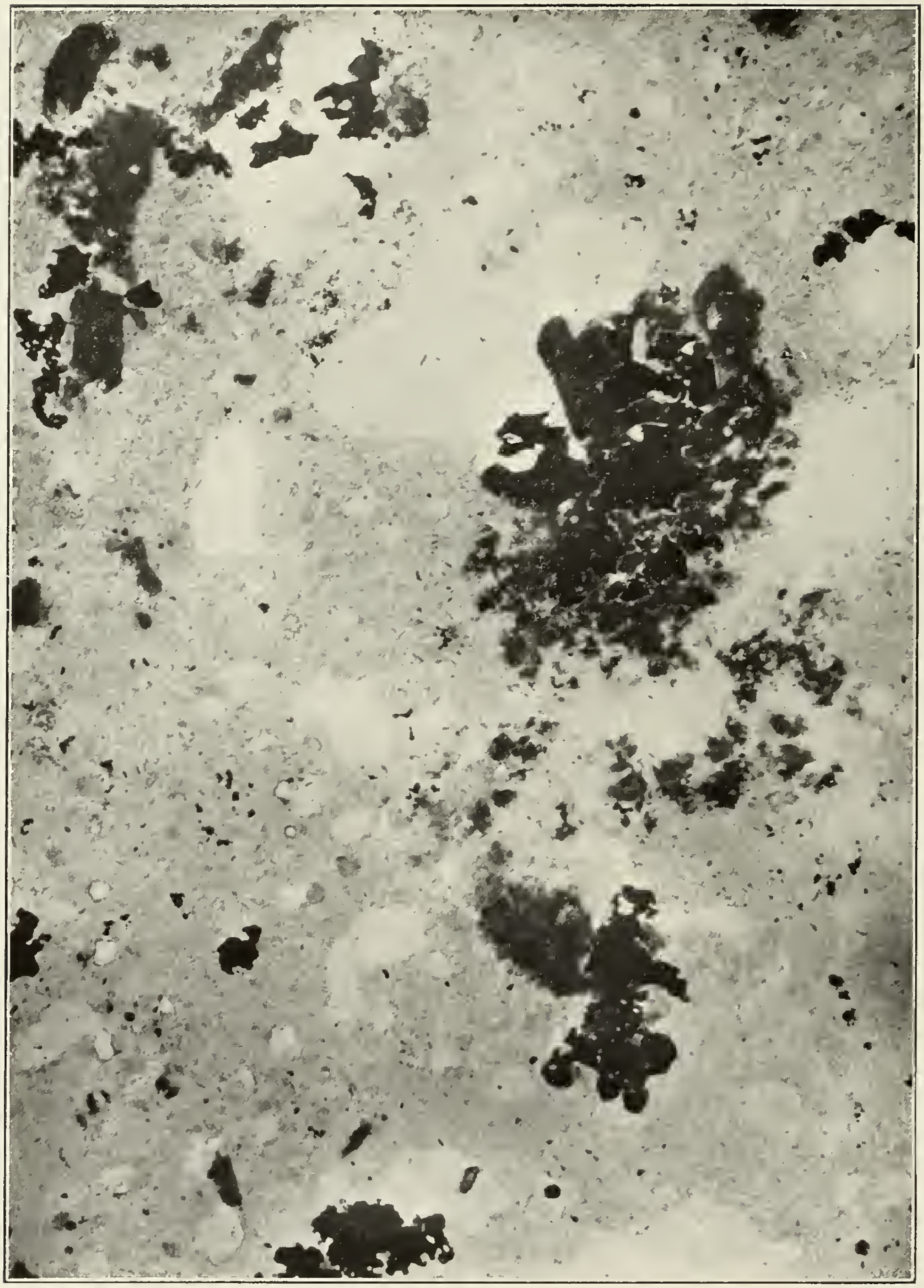
PLATE VII.



Spotted Acidic Tuff, or Tufaceous Mudstone, Tokatea Hill Series, No. 5 Level, Royal Oak Mines, Coromandel.

Magnification, 50 diameters. Work of Mr. Alexander McKay, F.G.S.

PLATE VIII.



ALTERED RHYOLITE (?), TOKATEA HILL SERIES, MANAIA RIVER.

Magnification, about 33 diameters. Work of Mr. Alexander McKay, F.G.S.

The term " adinole " was applied by Sollas to these rocks subject to subsequent chemical analyses showing the necessary soda-content. These analyses, however, do not warrant the applicability of the term. This petrologist also remarks, " If not an adinole it might perhaps be termed a ' grauwacke,' though I scarcely think this is a quite appropriate name."*

The petrographical determinations leave little doubt that pyroclastic material of an acidic type contributed largely to the formation of these rocks, but it is impossible to determine to what extent the original sediments have been affected by metasomatic processes. While no specific names have been applied to these rocks in this report, they have been grouped under the heading, " Acidic tuffs and tufaceous mudstones." They occur in every area where the Tokatea Hill Series is developed—Whaiwango Creek, Tokatea Hill belt (forming the country rock of most of the mines), Success Hill – Tiki area, and Manaia Valley. The characteristic spotted rocks of the series have also been detected in the small left-hand branch of the creek draining the western flank of the Waitaia Ridge in the vicinity of the Waitaia Mine, but to what extent they occur in the workings of this mine has not been determined.

(*c.*) *Quartz Sericite Rocks* (*Altered Rhyolites* ?).—The quartz sericite rocks are pinkish-grey and cream-coloured, with ochreous stainings. The ochre-coloured portions sometimes show an irregular banding. They are fine or medium coarse in texture, not very hard, and break with an irregular fracture. These rocks wherever met with are considerably altered, and none of their constituent minerals are recognisable megascopically. Under the microscope they are seen to consist in the main of quartz and sericite. The quartz, which is much the more abundant mineral, occurs as mosaics varying in fineness but never very coarse, also as more isolated irregular grains some of which have a rhyolitic appearance. The sericite forms felt-like patches, the scales sometimes showing a radiate structure, and again occurs interstitial to the quartz grains. Some of the sericite-felt areas present more or less rectilinear boundaries, and show parallel striations between cross nicols; they may represent pseudomorphs of other minerals such as feldspar. Ferric hydrates form the ochreous patches which are conspicuous in the hand-specimens, and are probably due to the alteration of pyrite, which is still sparsely present. Some of the sections show a good deal of leucoxene and a few crystals of zircon.

The quartz sericite rocks are characteristic of the Tokatea Hill Series and have greatest development between Cadman Creek and Tiki Creek, forming conspicuous bluffs in the higher country and at the fork of the Tiki and Pukewhau Creeks. Similar bluffs with talus at their bases occur in the gorge of the Manaia Stream.

A rock which appears to show a transition between these and the type to be next described, occurs in the vicinity of the abandoned Blackmore's Mine on the Tiki–Opitonui Road, and has a parallel in certain rocks occurring near the north end of the Monte Christo Mine, Tokatea Hill.

The boundaries of the thick bands of this rock are less regular than the tuffs and tufaceous mudstones which are always associated with them, and they are apparently altered rhyolitic flow rocks. Sollas, as the result of petrographical examination, says, " It is tempting to think of these rocks as altered rhyolites."†

(*d.*) *Contemporaneous Rhyolites.*—The rocks considered under this heading are white or cream-coloured and frequently show ochreous stainings, while grey-coloured bands, suggesting fluxional structure, sometimes occur. The rocks are often porous, and show scattered grains of quartz, and drusy cavities.

Under the microscope some of these rocks show a very finely granular crystalline groundmass, consisting of quartz and sericite with scattered granules. In this groundmass quartz, as irregular corroded grains, occurs as phenocrysts. These grains show liquid and vapour cavities, and sometimes present bipyramidal forms surrounded by a secondary growth of quartz. The forms of certain areas rich in sericite and other secondary products suggest the former presence of feldspar. Sections cut from the banded rocks show streaks of mosaic quartz of different degrees of fineness. Grains of quartz

* Sollas and McKay: " Rocks of Cape Colville Peninsula," vol. i, 1905, p. 151.
† *Loc. cit.*, vol. i, 1905, p. 137.

of rhyolitic habit, and sericitic areas also occur. Black dust in banded alignment is present, and certain opaque dust, in accumulations having circular outlines, suggests possible spherulitic structures. These rocks are undoubtedly silicified rhyolites.

These rhyolites have their greatest development on the eastern slopes of the Tokatea section of the main range, associated with felsitic tuffs apparently as interstratified bands having a west-north-westerly strike, and dipping to the southward. Two of the best exposures occur in the gorge of the Harataunga Stream, one a little distance above and the other a little distance below the junction with this stream of the creek on which the Royal Oak battery is situated. Another has been exposed in the excavations for the Royal Oak compressor-station situated on the bank of the Harataunga Stream 20 chains above its junction with Waikoromiko Creek. What is apparently one of these bands appears in the workings of the Monte Christo Mine on the same side of the main range at an elevation of some 1,200 ft. Bands of these rocks also occur in the gorge of the Manaia Stream.

The Moehau Series.

General Statement.

The term "Moehau Series" has been assigned in this report to the argillites and grauwackes, which have their greatest development in the Moehau Range in the northern portion of the subdivision. The rocks of this series cover a larger area than those of any other series of sedimentary rocks in the subdivision.

Age and Correlation.

These rocks have so far afforded no palæontological evidence. Park refers to what he considers "indistinct coralline structure from the black shaly rocks at Stony Bay" on the eastern coast-line of the Moehau district, but states that "the remains are too obscure to fix the age of the rock."* During the course of the present survey rock-specimens showing structures having a general resemblance to fragmentary corals were collected from the Stony Bay locality, but further examination did not favour these structures being regarded as of organic origin.

Many of the previous writers on the geology of this area refer to the strong lithological resemblance which the rocks under consideration present to fossiliferous (Carboniferous) strata in the Maitai Valley, Nelson. The term "Maitai Series," implying a Lower Carboniferous age, has therefore frequently been applied to these rocks of the Hauraki Peninsula.

Reference has already been made to the relationship of the Moehau Series to the Tokatea Hill Series, and both of these, until more definite age-evidence is available, may with propriety be designated Pre-Jurassic, as they underlie rocks of the Manaia Hill Series, which at the typical locality contain Jurassic fossils.

General Distribution.

The rocks of the Moehau Series have, within the subdivision, their maximum development in the Moehau and Colville Survey Districts and in the vicinity of Cabbage Bay.

The major area may be considered as that portion of the peninsula lying to the west and north-west of a line drawn from the western coast-line at the mouth of Kairaumati Creek (Cabbage Bay) north-east for a mile and a half, and thence in a general direction north 26° west to the south headland of Stony Bay on the eastern coast-line.

Within this area intrusive rocks and a few small patches of younger sedimentaries and effusive volcanic rocks also occur.

Continuous with the main area just described is a belt half a mile to one mile and a quarter in width, extending in a southerly direction from the Kairaumati Creek for a distance of four miles up the main valley of the Umangawha Stream, which drains into Cabbage Bay. Westward of the mouth of the Umangawha and its flood-plains these rocks again appear for a distance of some 40 chains on the southern shores of Cabbage Bay, and are here overlain by the breccias and agglomerates of the

* "The Geology and Veins of the Hauraki Goldfields" (J. Park), 1897, p. 15.

Beeson's Island Series. The rocks of the Umangawha Valley attain their greatest elevation (800 ft.) in Sutton Creek, one of the south-easterly branches of the main stream.

On the eastern side of the main divide, distant 60 chains from the Sutton Creek outcrop and at a nearly corresponding elevation, similar rocks are exposed in the headwater branches of the Omoho Creek; these further south give place to the Tokatea Hill Series, the contact being obscured by heavy surface débris.

Certain rocks in the Mangatu and Mataiterangi Creeks (Kennedy's Bay Valley) may belong to this series, but more resemble the Manaia Hill Series with which they have been correlated. Reference has also been made to the possible occurrence of minor areas of the Moehau Series involved with the Jurassic sediments in the lower portions of the Waiau and Matawai Valleys.

GENERAL STRUCTURE.

The disposition of the strata as a whole in the main Moehau – Cabbage Bay area, where these rocks have their greatest development, is difficult to determine owing to the local deformations which the beds have frequently undergone as the result of numerous igneous intrusions. More especially is this true of that portion of the area lying to the westward of Moehau Range. Throughout the whole of this area the beds would appear to preserve a general strike varying from a few degrees east to a few degrees west of the meridional line and a prevailing dip to the westward, though considerable local irregularities occur in the outcrops observed on the western side of the mountain divide between Hope Creek and Port Jackson. The only marked exception to the prevailing westerly dip appears on the northern coast-line just westward of Sugar Loaf Rocks. In this locality the strata, for a distance of 20 chains, dip regularly at fairly low angles to the eastward, the minor anticline and syncline produced by the flexure having a pitch to the northward. A boss of intrusive rock, which denudation has not yet exposed, may possibly account for this minor irregularity. Transverse to the prevailing strike, the beds extend over a distance of five miles, and the average westerly dip is about 50°. An isoclinal folding of the strata can hardly be assumed to account for the great thickness of sediments which apparently exists here, as the angles of inclination are frequently low; moreover, no metamorphism of the rock is apparent apart from that locally effected by the intrusives. Strike faults might be assumed to partly account for the persistent westerly dip, but such faults of any considerable magnitude, if they do exist, have not been detected. The whole exposure is probably the westerly limb of the main anticlinal fold, to which reference has been made in the opening section of this chapter.

The strata are in general thin-bedded, the argillites and grauwackes often occurring in rapid alternation. Zones showing the effect of crushing and movement are in places noticeable. The yielding of the layers of argillite has given rise to crumbling slickensided fragments, while in the harder grauwacke numerous joints and fractures have resulted, causing the rock to break into small cuboidal or rectangular fragments. A recementing of these grauwacke fragments by siliceous material has in places formed friction or crushed breccias.

Sharply marked fault-lines are not uncommon, but those observed are only of minor magnitude.

The numerous intrusions of diorite, porphyrite, and andesite, which occur as dykes and sheets in the rocks of the Moehau Series, will be specially considered in a subsequent chapter.

PETROLOGY.

Preliminary Statement.—The sedimentary rocks forming the series under review show a marked uniformity throughout their whole areal extent. They exhibit little variety, consisting as already indicated of argillites and grauwackes with the usual lithological gradations between these two more or less definite types. Friction breccias are only of local occurrence, marking zones of crushing and rock-movement. The argillites and grauwackes at and near the contacts of the larger intrusive masses frequently show the effects of thermal metamorphism, but beyond the influence of these intrusives, no metamorphic alteration is apparent.

The Argillites.—The argillites are black or greyish-black in colour, and less frequently bluish or yellowish grey. The weathered rocks generally assume a yellowish-brown or buff colour, and along joints and bands where all the iron-compounds have been leached out a white powdery mass often

results. Segregations of the rusty-coloured hydrous ferric oxides frequently form veinlets ramifying in all directions. The fresh rocks are well compacted, occasionally show lamination, and are in general uncleaved.

Under the microscope, clastic quartz and plagioclase feldspar are recognisable with fine interstitia. material, which was not resolved even under high magnifications. Fine mosaics of secondary quartz with some sericite, or again irregular calciferous patches and veinlets, are not uncommon. Some of the sections showed fine dark dust arranged apparently along planes of shearing.

The argillites in the vicinity of many of the igneous intrusions have been considerably baked and indurated, and in many cases appear to have been subjected to silicification. Some of the very fine-textured siliceous rocks closely resemble lydian-stone. Cherty argillites, however, occur as narrow beds in areas showing no intrusive rocks, and these are apparently in part chemical precipitates.

The Grauwackes.—The grauwackes differ mineralogically from the argillites only in the coarser nature of a great part of their clastic constituents, and in that, being less dense, they are generally somewhat lighter in colour. Under the microscope the sections cut show subangular and rounded quartz grains, sometimes with fluid inclusions in alignment; plagioclase feldspars with remains of albite twinning, extinction angle 19°/22°; occasional small bent plates of biotite and muscovite; also a fragmentary crystal or two of pyroxene and zircon. Ilmenite altering to leucoxene sometimes occurs, also dark, finely-comminuted magnetite. Secondary chlorite and sericite are present throughout the finer groundmass. As in the argillites quartz or calcite forms fine ramifying veinlets or irregular patches. The mineralogical composition of these rocks suggests that the detrital material of which they are composed has been derived largely from the erosion of an area of crystalline rocks.

Specimens of a grauwacke selected from within one of the aureoles of contact metamorphism show a considerable development of secondary biotite as small ragged laths and irregular scales fairly uniformly distributed throughout the rock, and with the long axes of the individuals showing a general alignment. Muscovite, epidote, and chlorite are also present, but to a much lesser extent.

The Manaia Hill Series.

GENERAL STATEMENT.

The rocks of the Manaia Hill Series form non-continuous belts on each side of the mountain divide. They consist of fine conglomerates, grits, grauwackes, and shaly argillites, and present a marked uniformity in mineralogical composition wherever encountered in the subdivision. The series is named from Manaia Hill situated between the Coromandel and Manaia Harbours, a locality where the rocks are typically developed, and where they have yielded most of the identifiable fossils described.

AGE AND CORRELATION.

The rocks of the Manaia Hill Series have been involved with those of the Moehau and Tokatea Hill Series in great earth-movements. The general distribution of the Manaia Hill rocks as belts forming the lower flanks of each side of the mountain divide, is significant. This would imply their superposition on the rocks of the two older series, either on the assumption that the strata forming the range are disposed in the main with anticlinal arrangement, or that the sediments which formed the Manaia Hill rocks were deposited on each side of a ridge of land consisting of Tokatea Hill and Moehau rocks. The former is the more feasible hypothesis.

The relationship of the Manaia Hill Series to the Tokatea Hill and Moehau Series has been considered in earlier sections of this chapter. In correlating the various isolated areas on both sides of the peninsula with the undoubted Jurassic strata of the Manaia Hill, the writers have relied almost entirely upon the physical and mineralogical character of the rocks. At Tawhetarangi, twelve miles north of Manaia, there was discovered in the fine conglomerates a small fragment of the prismatic layer of a bivalve shell(?) agreeing in structure with similar material from Manaia Hill. This discovery affords considerable support to the deductions based on physical and mineralogical data.

The widespread occurrence of fine conglomerates and grits is evidence of sedimentation in comparatively shallow water. Igneous material has contributed very largely to these sediments. Part

PLATE IX.

Inoceramus Haasti (Hochstetter), from Conglomerate, Manaia Hill Series, Manaia Hill.
Magnification, 3 diameters. Work of Mr. Alexander McKay, F.G.S.

Belemnites Sp. (Transverse Section), from Conglomerate, Manaia Hill Series, Manaia Hill.

of this igneous material consists of fine detritus, with occasionally rounded pebbles exceeding an inch in diameter derived from diorites and porphyrites, but more remarkable is the very large part which flow andesites and flow rhyolites have taken in the formation of all these grits and conglomerates. It is difficult to speculate as to the source of this great amount of volcanic material, but the following facts appear to bear on the question. The Tokatea Hill Series has been shown to contain interstratified rhyolites, and is largely intruded by numerous dykes of porphyrite and diorite. In this connection it is significant to note that intrusions occur much less frequently in the Manaia Hill Series than in the Tokatea Hill and Moehau Series ; moreover, those that do occur are less crystalline than most of those in the older rocks, and are probably of Tertiary age. It would appear, therefore, that the sediments which formed the Manaia Hill Series may have been derived from a land-mass consisting of rocks equivalent in age and lithological character to those of the Tokatea Hill and Moehau Series ; whilst the great sheets of andesitic lavas which must have existed, have probably as their hypabyssal analogues some of the diorite and porphyrite intrusives of the existing areas of these Pre-Jurassic rocks.

Fossils were discovered during the course of the present survey in these rocks at Manaia Hill and at Tawhetarangi. At Manaia Hill the fossils were collected from the fine conglomerates of the road quarry, situated on the north-west side of the main Thames-Coromandel Road, at an elevation of 325 ft., on the fall of the hill to Manaia Harbour. The fragmentary fossil from Tawhetarangi was obtained from a conglomerate band occurring within the tide-marks 7 chains south of the mouth of Tawhetarangi Creek.

The fossils were submitted to Professor A. P. W. Thomas, of the University College, Auckland, for identification and description. His report, which follows *in extenso*, establishes the fact that the strata are not older than Jurassic, and are approximately of the same age as the Putataka beds of the New Zealand sequence—Upper Jurassic(?).

Report on the Fossils of the Manaia Hill Beds (Coromandel).

By Professor A. P. W. Thomas, M.A., F.L.S., F.G.S.

The fossils received for examination were contained in thirteen fragments of conglomerate, twelve of these being from Manaia Hill and the remaining one from Tawhetarangi. The pebbles of the conglomerate are of quartzose and other hard rocks, whilst the matrix itself is very hard and of irregular fracture, so that it is very unfavourable for the extraction of the fossils.

The fossils consist of :—

(*a.*) Two casts of fragments of Inoceramus.
(*b.*) Half a dozen fragments of Belemnite guards.
(*c.*) Fragments of calcite in regular parallel prismatic fibres, probably portions of the prismatic layer of a bivalve shell. This fossil occurred in the single specimen from Tawhetarangi, agreeing in structure with similar material from Manaia Hill.

In addition, one piece of the conglomerate included a calcareous fragment with markings which might be suggestive of a shell. There is reason to believe, however, that this specimen is not of organic origin.

Inoceramus Haasti, Hochstetter.

Hochstetter. "Neuseeland," p. 190.
Zittel. "Novara-Expedition," Geologischer Theil, band i, abth. 2, p. 33, tafel viii, fig. 5, *a*, *b*, *c*.

The Inoceramus appears to belong to this species. It is represented by casts of two fragments. One fragment, however, is of considerable size, and reproduces the coarse concentric rugæ and curvatures of *I. Haasti* in so characteristic a manner that I have little doubt that the identification is correct. An identification from such material cannot, however, be regarded as completely satisfactory, and must be held to be provisional.

This species was first found by Hochstetter in strata of sandstone and conglomerate near Takatahi, on the south side of the Kawhia Harbour.

Belemnites sp.

The fragments of Belemnite guard were firmly cemented in a hard matrix, which could not be detached from the softer Belemnite. Hence the characters have to be deduced from the weathered surfaces or from cut and polished sections. The fragments had evidently been rolled and subject to injuries on their surface before being buried, whilst some of the specimens have clearly been broken by the compression of the neighbouring pebbles. Nevertheless, some good cross-sections were obtained, showing the usual radially fibrous structure of a Belemnite guard, whilst the

concentric lines of growth are numerous and conspicuous, as many as seventeen being counted along a radius of 6 mm. The cross-sections are usually circular, with central axis of growth; one section is very slightly oval.

The most perfect specimen is about 25 mm. in extreme length and 12 mm. to 13 mm. in diameter. The smallest section is 4 mm. only in diameter; others are of intermediate size. So far as these specimens can decide, the species did not attain a large size.

By combining the characters seen in the different fragments, which seem to have belonged to one species, we may infer that the guard was of generally cylindric form, possibly becoming slightly compressed towards the alveolus. None of the fragments, however, actually show the alveolus.

It would probably be difficult to absolutely fix the specific identity of a Belemnite from such data as are here afforded. Nevertheless, I have been struck with the similarity of the sections with those of an undescribed species of Belemnite which I have collected around the Kawhia Harbour and in the country north of the Raglan Harbour. The number of species of Belemnites recorded from the North Island is exceedingly limited, indeed the only one hitherto described is *Belemnites Aucklandicus*, Hauer.* The undescribed species referred to is in some localities associated with with *Belemnites Aucklandicus*. It is distinguished by a rather fusiform guard, cylindrical for the distal half of its length, but becoming gradually compressed laterally, as the alveolus is approached. The cross-sections are therefore circular at first, whilst those across the alveolus are strongly ovate. The narrow but rather deep ventral canal is confined to the alveolar end; the lines of growth are very numerous and distinct. The specimens may reach 3 in. or 4 in. in length; the thickness of the guard in the largest specimens is about 12 mm. The species is therefore quite distinct from *B. Aucklandicus*, in which the ventral canal is rather broad, and reaches almost to the point of the guard, whilst the growth-lines are few. It appears to me that it is highly probable that the Manaia belemnites belong to this second species from the Putataka beds, or at any rate to a closely similar species.

If the above identifications be correct, it follows that the Manaia beds are of approximately the age of the Putataka beds, in which *Inoceramus Haasti* and the belemnite referred to are found. Hochstetter was in doubt as to whether these strata were of Lower Cretaceous or Jurassic age. In the map of the country around Kawhia Harbour, published by Hochstetter, the strata are described as probably Neocomian, but the fossils were described by Hauer as Jurassic. Zittel observes,† in summing up the discussion of the age of the beds, that the distinctly Jurassic character of *Belemnites Aucklandicus*, and the occurrence of *Aucella plicata* and *Placunopsis striatula*, favour the reference of the beds to the Jurassic system, although *Inoceramus Haasti* and *Ammonites Novo-zealandicus* have more likeness to Cretaceous species. It may be added that a species of Actinoceramus, a characteristic Cretaceous genus, is associated with *B. Aucklandicus* at the Waikato Heads.

The Putataka beds would seem, therefore, to be of mixed palæontological character, as compared with European strata. They have been generally described as Jurassic since Hochstetter's time. According to Sir James Hector‡ they contain Middle Oolite fossils. Only when the Mesozoic fossils of New Zealand have been systematically studied and described shall we be able to fix the precise homotaxial position of the Putataka beds.

For the present we may speak of the Putataka beds, and, if the above identifications be correct, of the Manaia conglomerates also, as belonging to the Upper Jurassic.

DISTRIBUTION.

The rocks of the Manaia Hill Series, as already indicated, form belts on each side of the main mountain divide. These belts are generally confined to the hilly country in the vicinity of the coast-line, and to the lower flanks of the main range. On the western side of the peninsula the most northerly area consisting of these beds is that which extends southward from a point on the coast-line near Tutahoa Creek to the valley of Paparoa Creek. In the lower and middle courses of the Waiau River, these rocks are again exposed and are continuous eastward into the valley of the Matawai and across Pukewhau Saddle to the source of Pukewhau Creek.

In the Awakanae Creek they are seen to overlie the andesites of its lower reaches and are again exposed as an inlier in the creek-bed at an elevation of 380 ft. The largest continuous area of these rocks extends from Mill Creek on the south shore of Coromandel Harbour to Manaia Hill and into the valley of the Manaia Stream and its tributaries. The western boundary of the area follows fairly closely the Thames–Coromandel Road between the Coromandel and Manaia Harbours.

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* "Novara-Expedition," Geol. Theil, bd. i, abth. 2, p. 29.
† "Novara-Expedition," Geol. Th. bd. i., abth. 2, p. 21.
‡ "Outlines of the Geology of New Zealand," p. 67.

On the eastern side of the peninsula the most northerly exposure of these rocks occurs in the right headwater branch of the Waikawau Creek, and very probably attains to the crest of the main divide in the low depression which exists in this locality. A mile further south they form a small inlier in the bed of Cousin Jack Creek. The conglomerates and grits characteristic of the series are again exposed on the north and south shores of Kennedy's Bay, and for a distance of two miles northward up the valley of the Whareroa Creek, which drains into this bay. The sedimentary rocks exposed in the Mangatu and Mataiterangi Creeks are doubtfully correlated with this series.

The Manaia Hill rocks again occur on the Kuaotunu Peninsula, being exposed at intervals on the coast-line for a distance of about a mile and a quarter to the north-east and a mile and three-quarters to the west of the mouth of the Kuaotunu Stream. Southward from the coast-line they extend up the valley of the stream, attaining on the Kuaotunu – Mercury Bay Road an elevation of 460 ft., and further eastward form the main Waitaia Ridge, with a maximum elevation of 1,032 ft. These Manaia Hill rocks of the Kuaotunu area probably overlie strata of the Tokatea Hill Series in the vicinity of the Waitaia Mine on the western side of this ridge; the boundary of the two series, however, owing to the great silicification and alteration of the sedimentary rocks, has not been determined.

It is quite possible that small areas of these rocks, other than those mapped, may exist within the limits of the subdivision, as the finer-grained sediments are in the field almost indistinguishable from some of those of the older series.

STRUCTURE.

The rocks of the Manaia Hill Series appear to form in the main the lower portions of the eastern and western limbs of a north-and-south-trending anticline. The lowest depression in the main range, near the headwaters of the Waikawau Creek, appears to be the only point where these rocks attain to the actual crest of the water-divide, a fact which may imply that a depression existed in this locality even in Jurassic times. The strata on the westward side of the peninsula show a prevailing dip to the westward or south-westward, while on the eastern side of the peninsula easterly dips apparently predominate. Subsidiary flexures appear to be present, but the irregularity of the folding renders it difficult to decipher the structure from the several isolated exposures of the series.

Faults of any considerable magnitude have not been detected. It will be noticed from an inspection of the maps accompanying this bulletin, that the beds of this series are much less frequently intruded by igneous rocks than those of the two older series. This fact becomes very apparent where areas of the Manaia Hill and Tokatea Series occur in close proximity.

PETROLOGY.

Preliminary Statement.—As already remarked, the Manaia Hill Series consists of conglomerates, grits, grauwaekes, and argillites, all of which when examined under the microscope show a wonderful uniformity in mineralogical composition. The strata are well consolidated and indurated, but show no metamorphic alteration except in so far as they have been locally affected by the few dyke rocks which intersect them.

Conglomerates.—The rock here classed as conglomerate is the one of most frequent occurrence in the Manaia Hill Series. It consists megascopically of a greyish-black gritty matrix, throughout which are interspersed numerous isolated lenticular and rounded fragments of a black siliceous slaty material. The rock is well consolidated. These slaty fragments in the most common rock-type seldom exceed ½ in. in their greatest dimensions, and constitute relatively to the matrix only a minor proportion of the rock. Much less frequently the angular and rounded slaty fragments are of greater dimensions than that specified, and their total bulk exceeds that of the matrix; the rock in this case generally assumes a dirty greenish-black colour.

Sollas examined sections made from several of the rocks occurring in the road quarry on Manaia Hill, and the general description is so applicable to the sections made from the many rocks collected by the writers, from widely separate localities within the subdivision, that this description is here quoted *in extenso*: "The rock consists almost entirely of worn and fragmentary material, with scarcely any interstitial cement. Pebbles of various kinds and all sizes occur, from those visible without a lens

down to others of microscopic dimensions. The interstices between the larger are filled with the smaller, and those between the smaller by others smaller still, and so on. Interstices unoccupied by fragments are thus rare, secondarily deposited material, such as carbonate and chlorite, occurring only in very insignificant quantity." *

The pebbles consist of—(*a.*) A dark-brown fine-grained grit or grauwacke, derived from older sedimentary rocks, with less frequently fragments of a calcareous grit. (*b.*) Andesites of several varieties, both micropœcilitic and hyalopilitic ; dacite ; the groundmass of flow rocks without phenocrysts. Most of these show marked fluxional structure. (*c.*) Rhyolites, generally silicified, some with traces of spherulitic structure, others showing banding with mosaic groundmass. (*d.*) Quartz, sometimes as bipyramids, again as large grains often containing liquid cavities ; plagioclase, as broken crystals with bent or broken twinning lamellæ, showing extinction angles of 10°/15° ; fragments of micropegmatite ; small zircons ; calcite occasionally as pseudomorphs after some other mineral.

These fine conglomerates, which consist so largely of the pebbles of igneous rocks, occur with remarkable persistency throughout all the areas of the subdivision mapped as Jurassic by the present survey. They are sometimes interstratified with their finer-grained equivalents—grits, grauwackes, and shaly argillites—or again they present a massive appearance. On account of the great amount of igneous detritus present, the rocks exhibit, on weathered surfaces, a white-speckled, tuff-like appearance.

Bands which may best be described as pebble-beds are frequently found associated with the well-consolidated conglomerates, or again occur interstratified with the grauwackes and shales. The pebbles in these interstratified bands are generally well rounded, are cemented by a very minor amount of interstitial material, and range up to 1½ in. in their greatest dimensions. They consist largely of grauwacke or siliceous slate, but igneous rocks—diorites, porphyrites, andesites, and rhyolites—are not uncommon. These beds are well exhibited on the coast-line between Tawhetarangi and Paparoa, also at Manaia Hill and in many places on the eastern side of the mountain divide where the rocks of this series are developed.

The Grits and the Grauwackes.—The grits and the grauwackes differ from one another only in the coarseness or fineness of their rock or mineral constituents. Neither class differs mineralogically in any respect from the fine conglomerates already described, and there exists every phase of gradation between the grits and these conglomerates. These rocks are of general occurrence, and may be specially mentioned as constituting at Tiki Hill and Kuaotunu the country rock of several of the mines.

The Argillites.—The argillites are black, yellowish-brown, chocolate, brick-red, or purple-coloured shaly rocks, which occur interbedded with the coarser sedimentaries and are mineralogically the finer-grained equivalents of these rocks. They are of very general occurrence. An interesting phase of these rocks is the bluish-brown foliated slickensided rock, which occurs in Waiau River about a mile and a half above the Matawai junction. Its peculiar almost schistose structure is evidently the result of pressure and shearing The brick-red or purplish-coloured shaly argillites are most conspicuous on the Pukewhau Saddle. The colours are due to iron in various stages of oxidation.

The micro-photographs (Plates 10 to 17) well exhibit the lithologic identity of the fine conglomerates collected from the various areas mapped as the Manaia Hill Series.

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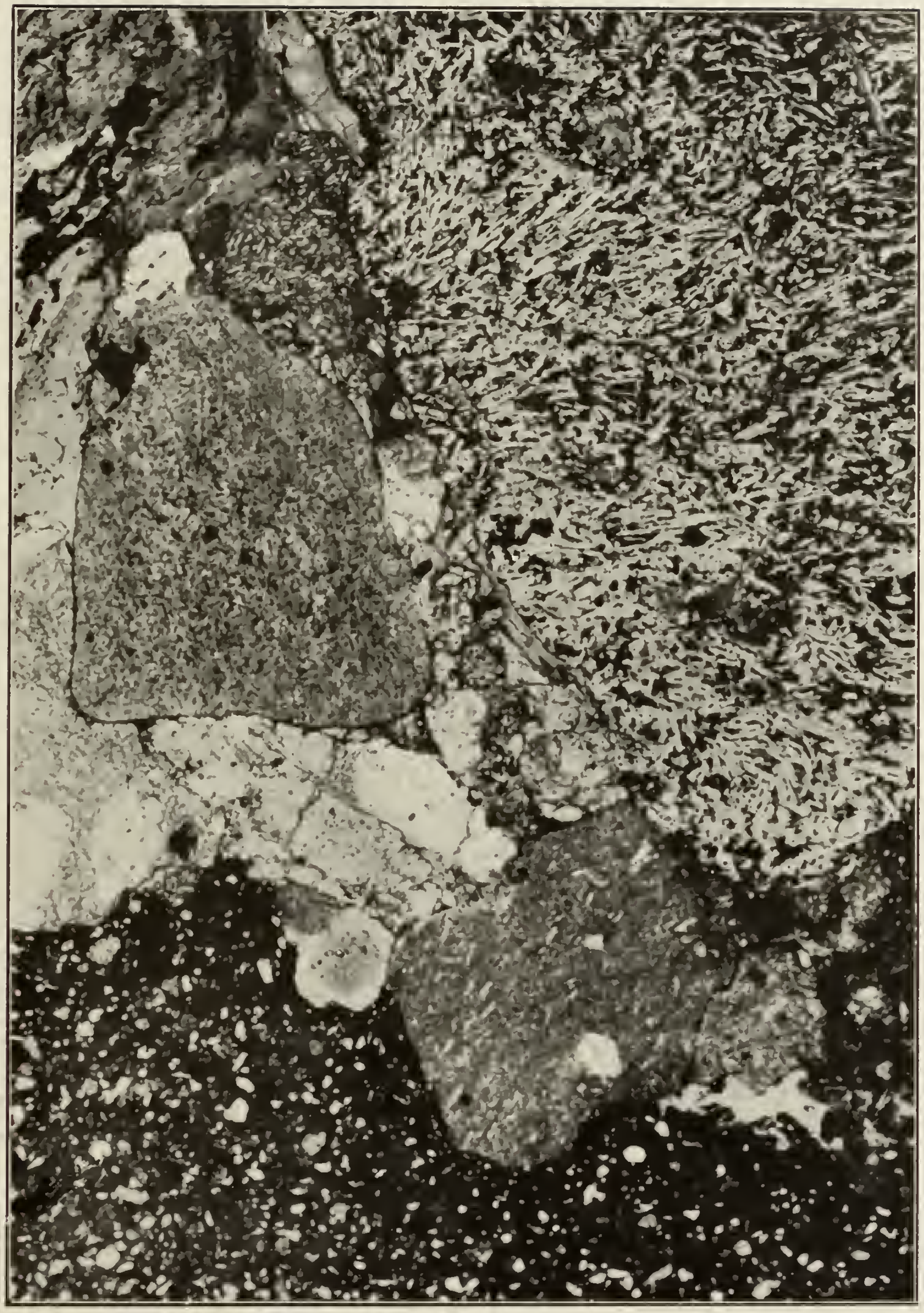
*Sollas and McKay: "Rocks of Cape Colville Peninsula," vol. i, 1905, p. 193.

PLATE X.



CONGLOMERATE, CONSISTING MOSTLY OF PEBBLES OF IGNEOUS ROCKS, MANAIA HILL SERIES, MANAIA HILL.

Magnification, 50 diameters. Work of Mr. Alexander McKay, F.G.S.

PLATE XI.

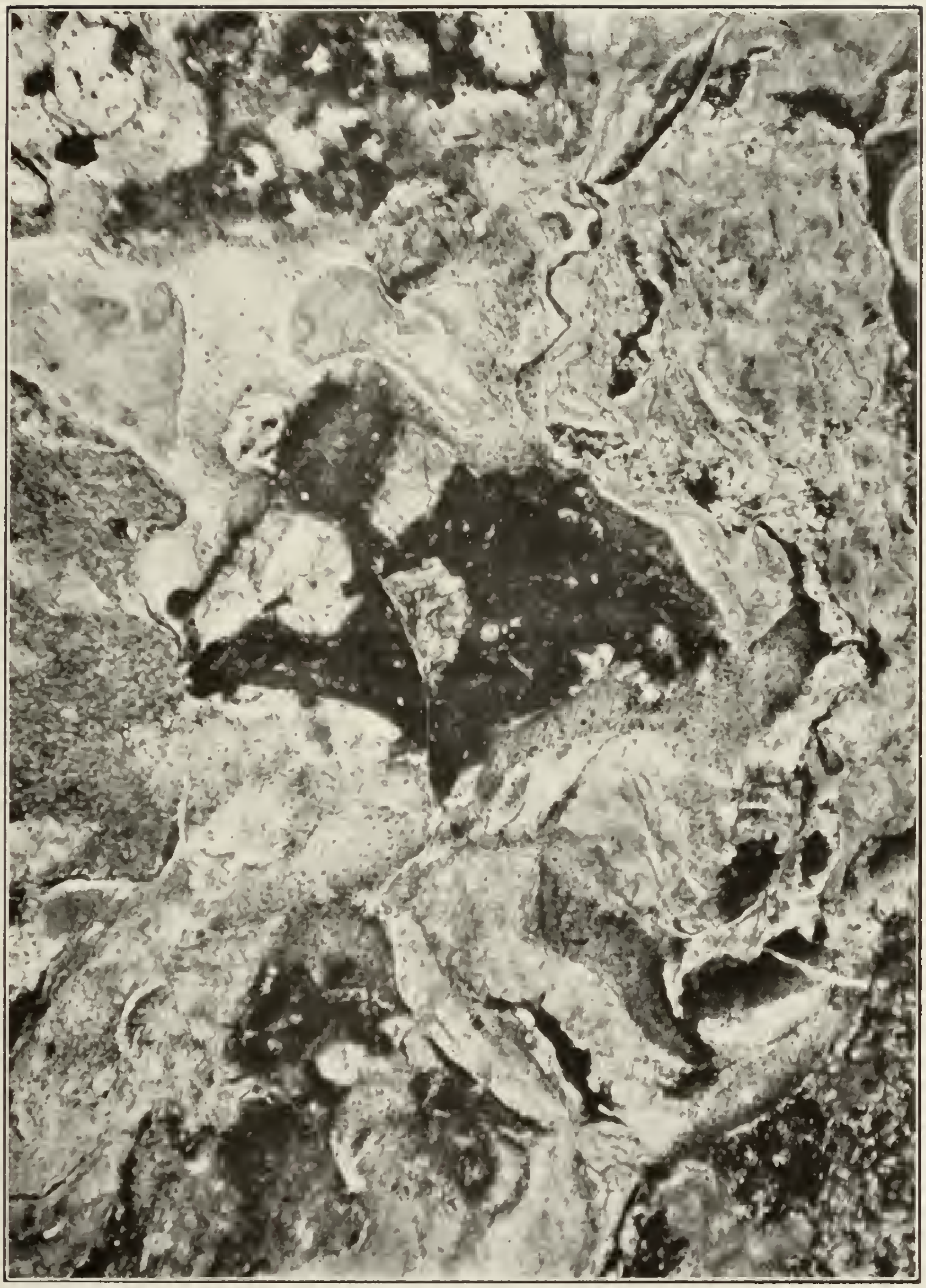
Conglomerate, consisting mostly of Pebbles of Igneous Rocks, Manaia Hill Series, Waiau River.

Magnification, about 33 diameters. Work of Mr. Alexander McKay, F.G.S.

PLATE XII.

Conglomerate, consisting mostly of Pebbles of Igneous Rocks, Manaia Hill Series, Waiau River.

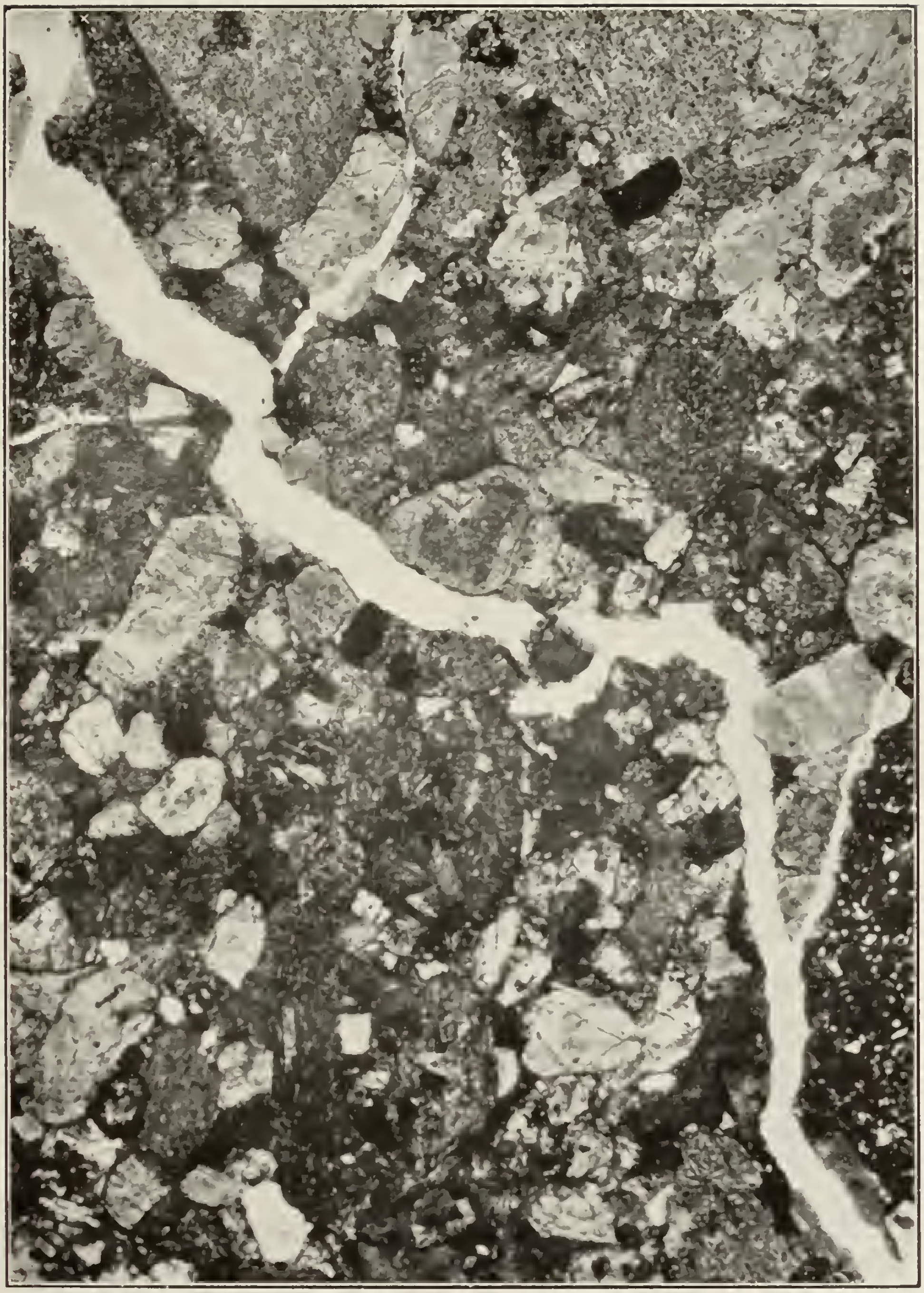
Magnification, about 33 diameters. Work of Mr. Alexander McKay, F.G.S.



Silicified Area in Conglomerate, Plate XII, Manaia Hill Series, Waiau River.

Magnification, about 100 diameters. Work of Mr. Alexander McKay, F.G.S.

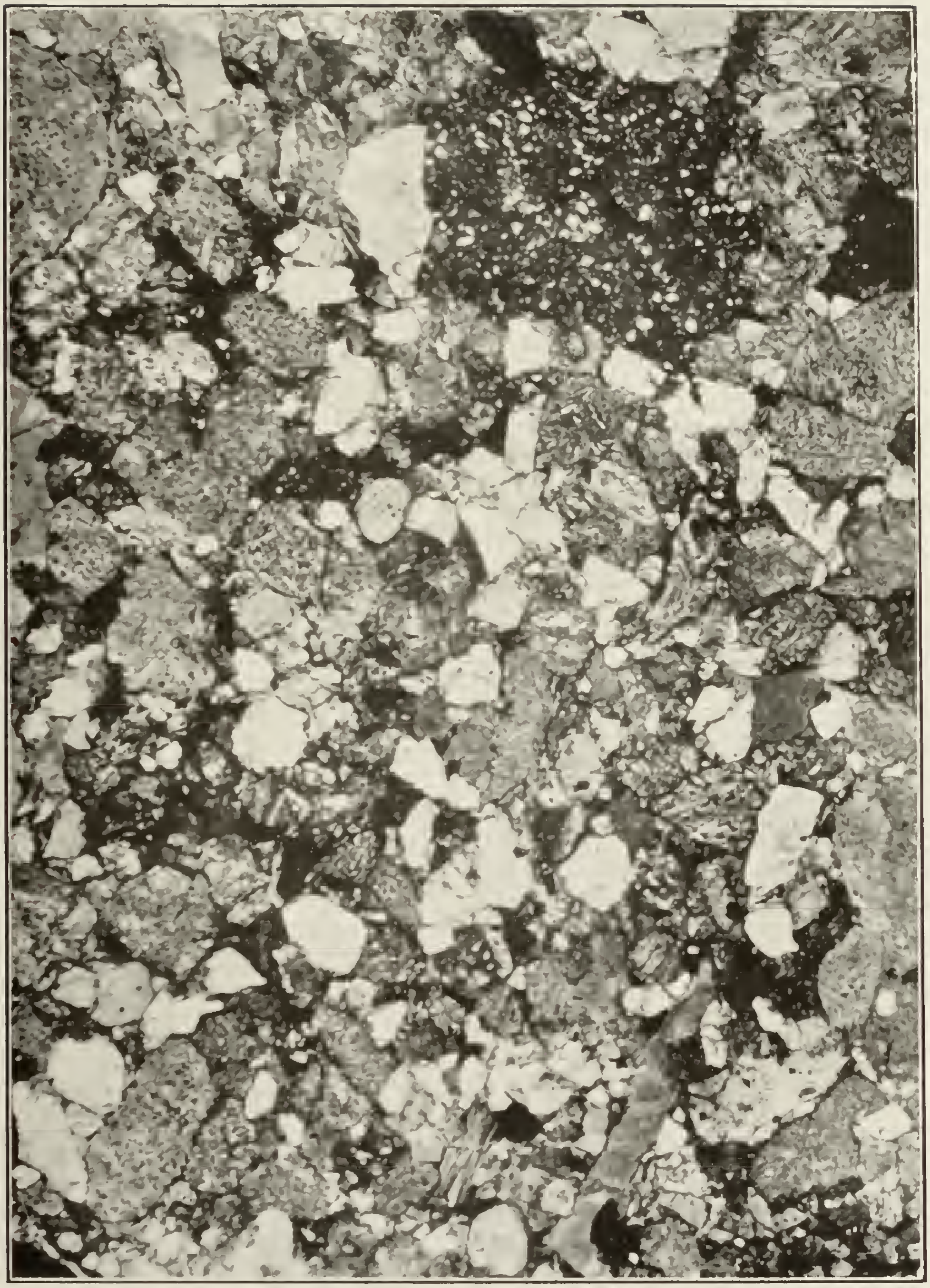
PLATE XIV.



Conglomerate, consisting mostly of Pebbles of Igneous Rocks, Manaia Hill Series, Upper Valley of Waiau River.

Magnification, about 33 diameters. Work of Mr. Alexander McKay, F.G.S.

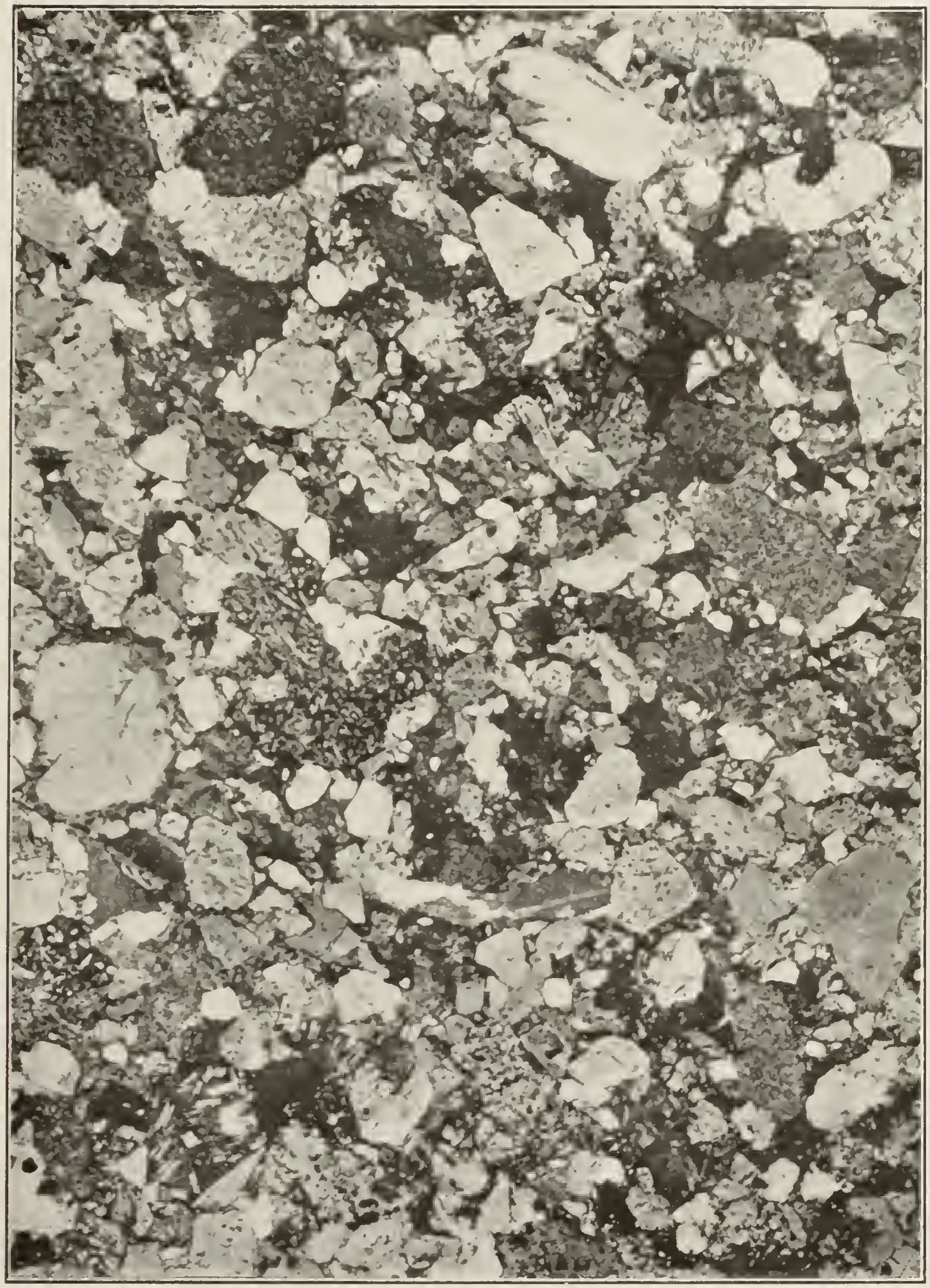
PLATE XV.



Conglomerate, consisting mostly of Pebbles of Igneous Rocks, Manaia Hill Series, Matawai Creek.

Magnification, about 33 diameters. Work of Mr. Alexander McKay, F.G.S.

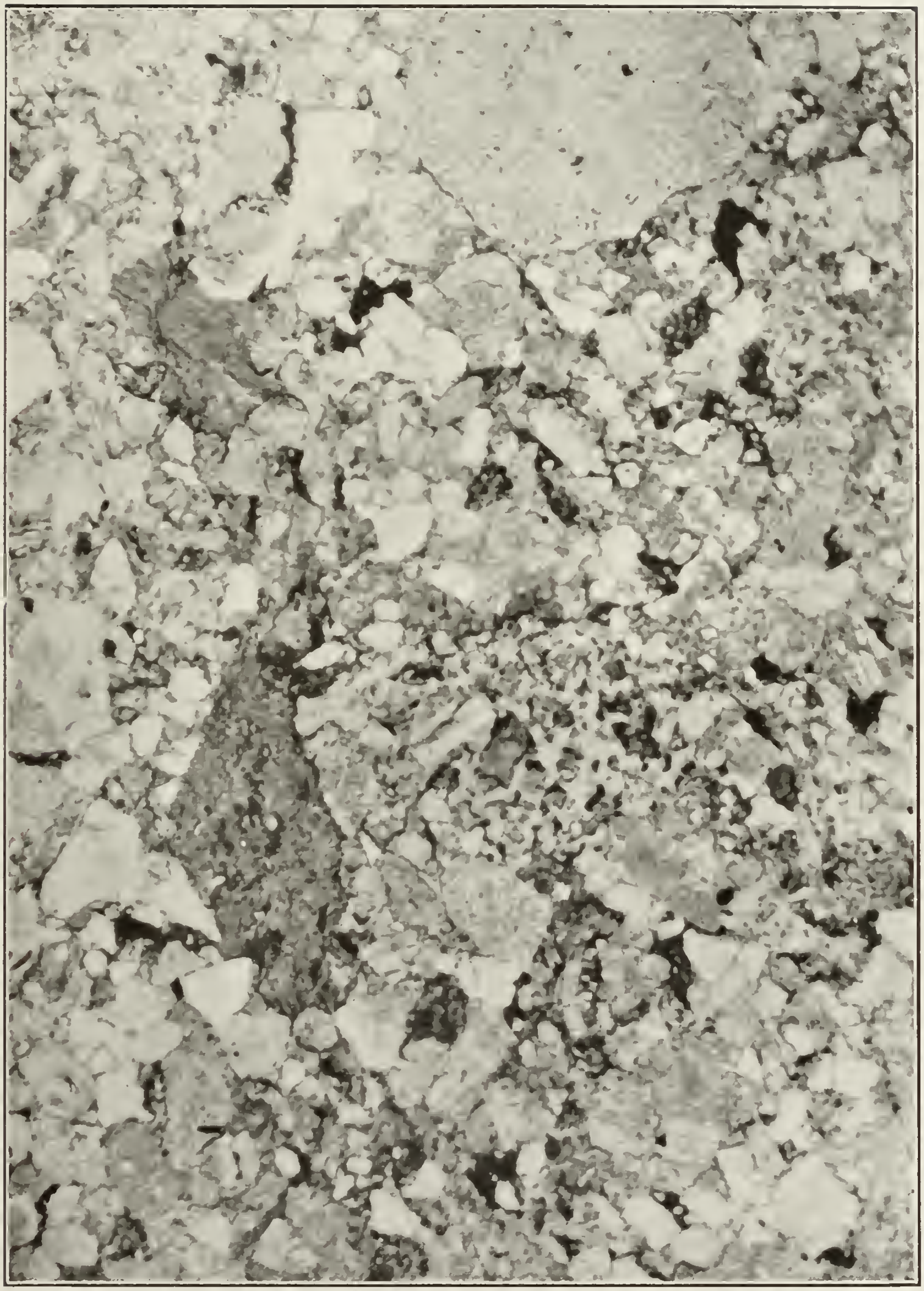
PLATE XVI.



Conglomerate, consisting mostly of Pebbles of Igneous Rocks, Manaia Hill Series, Try Fluke Mine, Kuaotunu.

Magnification, about 33 diameters. Work of Mr. Alexander McKay, F.G.S.

PLATE XVII.



Conglomerate, consisting mostly of Pebbles of Igneous Rocks, Manaia Hill Series, Kennedy's Bay.

Magnification, about 33 diameters. Work of Mr. Alexander McKay, F.G.S.

CHAPTER VI.

THE TOREHINE SERIES.

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Introduction	53	Age and Palæontology	54
General Distribution	53	Special Areas	55
General Structure	54		

Introduction.

The Torehine Series consists of two more or less distinct divisions :—

(*a.*) (Older.) Fluviatile and estuarine beds with coal-seams Conglomerates, sandstones, and shales, with coal-seams.

(*b.*) (Younger.) Marine beds.. .. .. .. Marly sandstones, calcareous sandstones, limestone.

Mere isolated patches of these stratified rocks—a series which formerly must have covered a considerable area of the subdivision—now exist. The only fairly complete sequence of both the older and younger group of beds, is that exposed at Torehine, some three miles in a straight line south of Cabbage Bay, and from this locality the series has been named.

Each of the other exposures shows only certain members of the series, and correlation of these particular beds with those of the typical locality is not always easy.

The Torehine Series is the equivalent of the principal coal-bearing formation of New Zealand, and contains abundant fossils which are considered to indicate a Lower Eocene(?) age for its beds. In the Coromandel subdivision the chief interest attaching to the series, apart from any economic value of its limestone and coal, is in connection with the stratigraphy of the peninsula. These beds lie unconformably between the folded and worn-down Jurassic and Pre-Jurassic sedimentaries, and the great pile of volcanics which constitutes, in the main, the auriferous rocks of the subdivision. The Tertiary age of the volcanics is thus demonstrated.

General Distribution.

The rocks of the Torehine Series occur as small isolated patches at several localities on both sides of the mountain divide. These are found at elevations varying from sea-level to 1,125 ft., and always overlie in marked unconformity the older rocks.

This distribution and mode of occurrence indicate that there must have been a relatively long period of denudation of the Torehine Series and older rocks contemporaneous with and subsequent to the elevation of the former above sea-level, and prior to the extrusion of the earlier Tertiary volcanics.

With the exception of two small patches, all the isolated areas covered by these rocks occur to the north of the southern boundary of the Harataunga Survey District. The most northerly exposure is that on the coast-line a mile and a half to the eastward of Cape Colville. The most extensive development of the beds is in the vicinity of Torehine, where they extend along the western coast-line from Anthony Creek to Tawhetarangi Creek, and inland to near the headwaters of both these streams. The beds near the heads of these streams are overlain by the "Second Period" volcanics, but again appear further eastward in Branch Creek, a western tributary of the Umangawha Stream flowing into Cabbage Bay. Within the Umangawha Valley the strata of this series are also exposed in Sutton Creek, and in the excavated cuttings of the Austral Road. A small area of the coal-bearing portion of the series occurs on the western flanks of Moehau Range between Waiaro and Neilson Creeks. On the eastern side of the peninsula, several small exposures are seen in the valley of the Omoho Creek which drains into Kennedy's Bay, and an isolated patch occurs near the head of Stewart Creek on the outer portion of the Kuaotunu Peninsula.

General Structure.

The strata of the Torehine Series invariably overlie, in marked unconformity, the folded and denuded Jurassic and Pre-Jurassic sedimentaries. The broken and irregular surface of the older basement rocks, underlying at Torehine and elsewhere the series under review, is proof of deposition on a land-mass of comparatively rugged topography. The general character of the beds further suggests that they were deposited during a period of gradual depression, or positive movement of the strand. The maximum stage of depression resulted in the formation of a coralline limestone, containing a few foraminifera, which is evidence that marine conditions then prevailed over certain portions of the present peninsular area.

Unlike all the older sedimentary rocks the strata of the Torehine Series are never disposed at very high angles. The beds of nearly all the widely separated exposures show a rather remarkable agreement in their strike and in the direction of their dip. The strike of the strata varies little from north-north-west, while the dip is to the east-north-east, though the angles show variation from almost 0° to 45°. The occurrences on or near both the eastern and western coast-lines of the peninsula are little above the present sea-level, whereas those further inland attain elevations exceeding 1,100 ft. on the flanks of the main dividing range.

The last great folding movement which has affected the area evidently postdated the formation of the Torehine Series, since the present position of these rocks cannot be accounted for by any simple tilting of strata. Although the rocks of the series considered are found directly overlain by volcanic rocks of both the "First" and "Second Periods," in only one instance has an intrusive been discovered actually intersecting them. This occurs in the lowest outcrop of the main Omoho Creek, and will be described later.

Age and Palæontology.

At Torehine many of the carbonaceous shales of this series contain leaf-impressions, but these are rather too poorly preserved to admit of identification. At Waiaro, however, abundant well-preserved leaf-impressions are found in the hard coaly shales associated with the coal-seams. These were investigated by Maclaren, who identified the following forms* :—

Blechnum priscum (of Ettinghausen) (*Alethopteris* of Hector).
Flabellaria sublongirachis (Ettinghausen).
Bambusites australis (Ettinghausen).
Fagus sp.

In the marine beds of Torehine, Branch Creek, and the head of the Umangawha Stream the following fossils have been reported by previous investigators—McKay (C.–9, 1897, pp. 48 and 49); Park ("Geology and Veins of the Hauraki Goldfields," 1897, p. 16); Maclaren (C.–9, 1900, pp. 12 and 13)—to occur :—

Protozoa :
Foraminifera (McKay, Park, Maclaren).

Cœlenterata :
Small Bryozoan corals (McKay, Park). Variety, *Flabellum* (McKay).

Echinodermata :
Pentacrinus stellatus (McKay, Park, Maclaren).
Hemipatagus tuberculatus (McKay, Park).

Mollusca :
Cucullœa (McKay, Park). *Cucullœa* sp. (Maclaren).
Ostrea wullerstorfii (McKay, Park, Maclaren).
Cardium(?) (McKay).
Venus (Park).
Turritella (McKay, Park).

* Maclaren: C.–9, 1900, p. 13.

Turritella gigantea (Maclaren).
Fusus (McKay, Park). *Fusus* sp. (Maclaren).

Vertebrata (Pisces):
Teeth of *Lamna huttoni* (Maclaren).

McKay* refers the rocks constituting the Torehine Series of the present bulletin to a Cretaceo-Tertiary age, whereas Park claims for them a Lower Eocene age.

Maclaren remarks as follows in connection with the leaf-impressions of the Waiaro beds, which apparently occur in the lowest horizon of the series: "On the whole the forms [described] resemble markedly the fossil flora of the Pakawau beds, Nelson Province. Von Ettinghausen very strongly insisted on a Cretaceous age for these Pakawau beds. . . . These land-fossils at Waiaro therefore contradict somewhat the evidence of the Torehine marine fossils, which are undoubtedly Lower Tertiary in age." The marine strata at Torehine, Maclaren refers to a Lower Eocene age.

A considerable number of fossil forms, representative of both the flora and the fauna of this series, were collected during the course of the present survey. Some of these forms have not previously been reported as existing here; they have, however, not yet been identified.

Pending the expert palæontological investigation necessary to settle authoritatively the question of the age of these particular horizons of the New Zealand sequence, the Torehine Series of the subdivision is assumed to be not later in age than Lower Eocene.

Special Areas.

Torehine.—In the vicinity of Torehine the beds of the series first appear on the coast-line about 4 chains south-west of Anthony Creek, and passing southward from here occur over a total distance of 55 chains (measured in a straight line). The most southerly outcrop is distant some 10 chains south of the mouth of Tawhetarangi Creek. The beds, for a distance along the coast-line of some 15 chains from the most northerly outcrop, pass below sea-level; but from here southward they are seen overlying in marked unconformity the older sedimentaries, for the first 8 chains as a continuous capping, then as more or less isolated patches. This main exposure extends inland for about a mile, a sinuous line marking the eastern boundary of the series with the overlying volcanic breccias of the "Second Period." At the main junction of the Tawhetarangi Stream another small patch of the beds of the series is exposed.

The strata where exposed on the coast-line at Torehine strike north 10° west, and dip to the east-north-east at angles approximating 15°. The sequence in ascending order is—

(*a.*) Fluviatile and estuarine	(1.) Conglomerates. (2.) Sandy shales with carbonaceous material.
(*b.*) Marine beds	(3.) Marly sandstone. (4.) Calcareous sandstone. (5.) Coralline limestone with foraminifera.

(1.) *The Conglomerates.*—The conglomerates have a maximum thickness of 30 ft. to 40 ft., and consist of boulders of grauwacke and argillite in a ferruginously stained arenaceous cement. The boulders are well rounded, and in the lower part of the bed they range up to four or five inches in diameter, while in the upper portion they are usually of smaller dimensions. These boulders are evidently of local origin, and no igneous rocks were discovered among them. The conglomerates attain their greatest thickness at Torehine Point, and small patches also occur some 16 chains to the north and 8 chains to the south of the mouth of Tawhetarangi Creek.

(2.) *Sandy Shales with Carbonaceous Material.*—The sandy shales generally overlie, but in places underlie, the conglomerate, and both were evidently being deposited contemporaneously. The shales enclose numerous dicotyledonous leaf-impressions, and also casts of small lamellibranchs and gasteropods. This is evidently the horizon in which coal should occur, but recent marine sand covers the junction of these beds with the main conglomerate band. A thin coaly parting, however, occurs in an outlier of these sandy shales a little further southward than Torehine Point.

* McKay: Sollas and McKay: "Rocks of Cape Colville Peninsula," vol. i, 1905, p. 43.

(3.) *Marly Sandstone.*—The marly sandstones have a greenish or purplish tinge, and grade imperceptibly into both the underlying sandy shales and the overlying calcareous sandstones. Most of the specimens of *Ostrea wullerstorfii* were collected from these sandstone beds near the coast-line, and at the main bifurcation of the south branch of Tawhetarangi Creek. The marly sandstones, especially in the vicinity of the overlying calcareous sandstone, contain concretions of a calcareous nature.

(4.) *Calcareous Sandstone.*—This sandstone is of a brownish-grey colour and fairly coarse texture, and includes here and there a small rounded pebble of grauwacke. The bed is approximately 50 ft. in thickness, and the rock may be regarded as a transition between the marly sandstone and the limestone. Most of the fossil mollusca which characterize the series are found in this horizon.

(5.) *Coralline Limestone.*—A limestone forms the highest visible bed in the series, and is exposed with a dip of 15° on the coast-line for a distance of 3 chains at right angles to strike, representing a thickness of about 50 ft.

The limestone is hard, compact, semi-crystalline, and of brownish-grey colour, glistening with minute facets of calcite. Under the microscope (see Plate 19) it is seen to consist largely of bryozoan corals, among which foraminifera are sparsely scattered.

The following is an analysis of a fair sample taken from various parts of the bed :—

	Per Cent.
Silica (SiO_2)	10·2
Iron-oxides and alumina	3·0
Lime (CaO)	48·8
Magnesia (MgO)	0·9
Carbon-dioxide (CO_2)	36·9
Undetermined	0·2
Total	100·0

There is no great area of this limestone exposed on the coast-line, and from the irregular contours of the old surface of the basement rocks upon which it rests it is doubtful how far it may extend inland. The fact, however, that it is the only limestone exposed on the coast-line within the limits of the Hauraki Gulf renders it of economic importance as a flux for metallurgical purposes. This limestone affords small characteristic outcrops in the valley of Anthony Creek about half a mile from the coast-line.

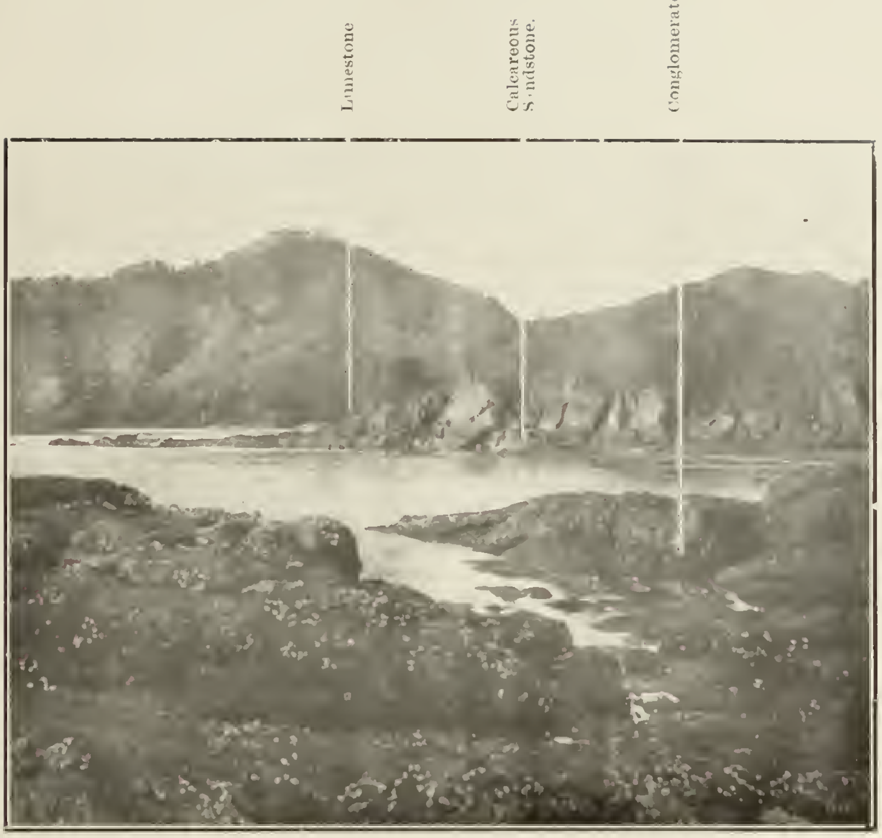
Branch Creek (Umangawha Valley – Cabbage Bay).—Branch Creek is the principal westerly branch of the Umangawha Stream and incises the inland side of the coastal range, which on the opposite and seaward side is scored by Tawhetarangi and Anthony Creeks. Marine beds of the Torehine Series occur in Branch Creek at an elevation of about 700 ft., and doubtless the strata here and at Tawhetarangi are more or less continuous under the volcanic rocks which form the greater part of this coastal range. Neither the basement argillites and grauwackes nor the lower members of the Torehine Series are visible in this locality. Marly sandstones passing upwards into calcareous sandstones are the rocks exposed at the lower levels in the creek-bed. These are overlain by a semi-crystalline coralline limestone, similar to that at Torehine.

Mr. D. V. Allen, who examined the area, reports that this limestone forms, at one point on the eastern side of the creek, a hill fully 100 ft. in height. An analysis of this limestone is as follows —

	Per Cent.
Silica (SiO_2)	3·50
Iron-oxide and alumina	2·30
Lime (CaO)	52·20
Magnesia (MgO)	0·80
Carbon-dioxide (CO_2)	40·50
Water and organic manner	0·70
Total	100·00

The beds of the Torehine Series in Branch Creek strike north 30° west, dip to the north-east at angles approaching 35°, and are exposed for a distance of 15 chains.

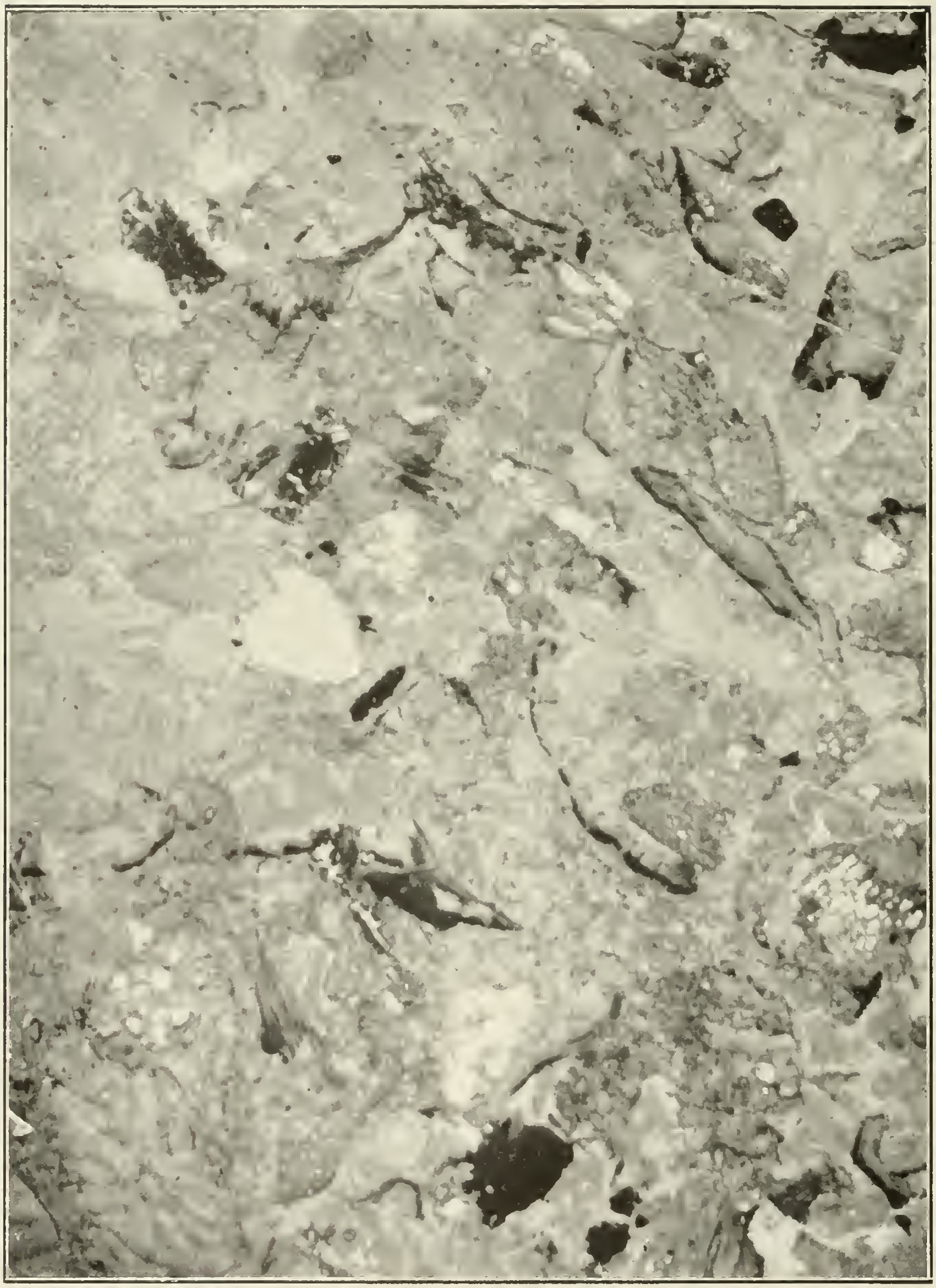
PLATE XVIII



TOREHINE, SHOWING STRATA OF THE "TOREHINE SERIES."

MOEHAU RANGE, VIEWED FROM TAWHETARANGI.

PLATE XIX.



Coralline Limestone, Torehine Series, Torehine.

Magnification, about 33 diameters. Work of Mr. Alexander McKay, F.G.S.

[To face p. 57.

Probably a larger area of limestone exists in Branch Creek than at Torehine, the limestone from which would furnish a reliable source of supply for metallurgical or other purposes, but in order to afford means of transport to the seaboard at Cabbage Bay a tram-line over four miles in length would be required.

Sutton Creek and Austral Road (*Umangawha Valley*).—At an elevation of about 900 ft. Sutton Creek, a branch of the Umangawha, crosses the Austral Road on the steep flanks of the main mountain divide. At this point, and for a distance of about 12 chains to the north-eastward, the sandy shales are found overlying the Pre-Jurassic sedimentaries. These shales, in places well laminated, enclose numerous reed-like plant-impressions and seams of carbonaceous material.

Some prospecting for coal has been done in this locality, and a seam which is said at one place to have shown a width of 5 ft. was located. Cox, who reported on this occurrence in 1881,* quotes the following analysis :—

	Per Cent.
Fixed carbon	59·02
Hydrocarbon	2·69
Water	2·31
Ash	35·98
Total	100·00

The high percentage of ash renders the coal of very poor quality, and the position and extent of the beds in which it occurs renders it certain that no seams of commercial importance can be expected to occur in this particular locality.

Waiaro Area.—On the western flank of the Moehau Range, at an elevation of 1,125 ft., an exposure of the lower division of the Torehine Series occurs on the spur between the valleys of Waiaro and Neilson Creeks. The beds, here resting on the rocks of the Moehau Series, strike nearly east and west, and dip to the northward at angles approaching 40°. They consist in the main of a considerable thickness of bluish-grey shales, with which are interstratified coal-seams, carbonaceous bands, gritty sandstone, and thin bands of conglomerate. This conglomerate resembles the finer conglomerate of Torehine, but contains small rounded pebbles of quartz.

Some prospecting for coal has been carried on here. In a drive some 75 ft. in length a coal-seam has been intersected dipping about 40° to the northward. The carbonaceous formation is about 5 ft. in thickness, but consists in the main of black coaly shales which break along joint-planes into sheeted masses presenting bright graphitic surfaces. The leaf-impressions, to which reference has been made in the palæontological section, were obtained from these shales. In the middle portion of this band of black shales, thin seams of glistening, friable, anthracitic coal occur. An analysis of this coal is as follows :—

	Per Cent.
Fixed carbon	90·85
Hydrocarbons	5·30
Water	0·85
Ash	3·00
Total	100·00

Total sulphur, 1·4 per cent.

This metamorphism of brown coal to its present anthracitic state would seem to indicate the presence of an igneous intrusion, but no such intrusion is visible, so that the phenomenon must be considered as probably due to intense pressure accompanied by thrust movement along the coal-seams. The sheeted structure in the shale and the slickensided graphitic surfaces support this conclusion.

Taking into consideration the locality of the occurrence and all local conditions, further prospecting for coal, notwithstanding its excellent quality, would not appear to be warranted.

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* Rep. G.S., vol. xiv, 1882, p. 41.

Area near Cape Colville.—The beds forming the area occurring on the northern coast-line, 95 chains to the east of Cape Colville, are of the marine type. They consist, in ascending order, of—

(*a.*) Shelly conglomerate (20 ft.), (highly fossiliferous).
(*b.*) Marly sandstone (15 ft. to 20 ft.).
(*c.*) Shelly conglomerate (2 ft. to 3 ft.), marly sandstone (10 ft.), shelly conglomerate (1 ft.).
(*d.*) Sandstones and mudstones.

The strata strike north 60° west, dip to the north-east at angles of 35° to 45°, and overlie a broken irregular surface of the Moehau rocks.

Omoho Valley (*Kennedy's Bay*).—In the main valley of Omoho Creek and that of its southern branch the Mangakotukutuku, small isolated patches of the Torehine Series occur at elevations ranging from 275 ft. to 550 ft. above sea-level.

The beds represented here are the greenish-grey marly sandstones, and these, in the lowest exposure within the main creek, have instratified with them a band of very dark-coloured limestone, which is about 10 ft. thick. Immediately under the limestone is a thin calcareous layer crowded with *Ostrea wullerstorfii.*

These remnants of the Torehine Series all lie directly on the old folded sedimentary rocks, and most of them appear to occupy depressions on the old surface. The coal-bearing division of the series is not represented in this locality. Rhyolitic tuffs and breccias, in continuity with the belt which appears on the Cabbage Bay side of the main divide, here constitute the overlying rocks.

An andesite dyke, intersecting both the old basement rocks and the beds of the Torehine Series, is well exhibited in the lowest exposure of the Omoho Creek bed.

Stewart Creek (*Kuaotunu Peninsula*).—A small exposure widely separated from all those previously described is that found in Stewart Creek near the outer end of the Kuaotunu Peninsula. The beds here occur at an elevation of about 60 ft. above sea-level, and form an inlier in volcanic rocks of the Beeson's Island Series. The older sedimentaries or basement rocks are not exposed in the bed of this creek, but show on the coast-line near its mouth. The outcrop is to be correlated with the lower divisions of the Torehine Series, and consists of brown sandy shales and fine grits, with associated carbonaceous bands. Coal occurs in these shales, but only as seams an inch or less in thickness. Shallow test-pits have been sunk at various points in the lower part of the valley without revealing any increase in the thickness of these seams.

CHAPTER VII.

LOOSELY CONSOLIDATED AND UNCONSOLIDATED DÉBRIS.

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General Statement.

Deposits consisting of loosely consolidated and unconsolidated débris do not cover a relatively great area of the subdivision. They are not deeply incised, and natural sections of other than the superficial portions are not obtainable. The greater bulk of these deposits occupy the floors and embayments of the larger valleys, and rise with very gradual slopes towards the valley-flanks and the foothills of the ranges. Narrow belts also occur along the more exposed coast-lines extending from the littoral zone to the base of the elevated country. The maximum age of the débris is undeterminable, but in any particular locality the deposits are more recent than the youngest effusive rocks seen in that locality, and from the nature of the débris it has been considered as varying in age from Pre-Pleistocene to Recent.

Fluviatile, lacustrine, and littoral deposits may be distinguished, together with accumulations of rock talus and wind-blown sands.

Fluviatile Deposits.

The fluviatile deposits constitute the high level terraces and the more recent flood-plains of the various streams, as well as the gravel-beds, gravel-bars, and beaches of the actual watercourses. With these should also be included the fan deposits of certain high-grade streams. These deposits often coalesce one with another to form sloping strips of country skirting the ranges.

All the high-level river-terraces worthy of note appear to be confined to the western side of the peninsula. These are rarely deeply channelled and, in general, merge insensibly into the more recent alluvium. The deposits consist of arenaceous and argillaceous material, through which are scattered rounded andesitic boulders more or less decomposed, grauwacke and argillite boulders rather better preserved, and fragments of quartz, chalcedony, wood-opal, &c.

In the vicinity of Coromandel Township high level terraces fringe the foothills of the range, and in places attain elevations of 40 ft. or more. The largest of these extends from the left bank of the upper course of the Whangarahi Stream (sometimes known as Kapanga Stream) to the right bank of the Karaka Stream, a distance of about a mile. Several high level terraces occur in the Waiau Valley near the locality where the stream enters the coastal flat. They here extend northward from the vicinity of the Tiki – Mercury Bay Road, to the flanks of the hills where the Tiki Creek (a tributary of the Waiau River) leaves its mountain course. Those portions of the terraces lying to the south of Tiki Creek have in the past attracted attention on account of their auriferous character, and the numerous old tunnels bear testimony to a great amount of prospecting. Sluicing operations in Sawmill Creek, which in its lower course cuts through these terraces, yielded a few payable returns from detrital gold and highly auriferous quartz boulders. The auriferous " wash " which occurred here is attributable to a reconcentration of the older terrace-gravels through the agency of the small stream. The auriferous quartz of these terraces has evidently been derived from the veins in the higher country, in the valleys of Pukewhau and Tiki Creeks, and possibly (judging by the occurrence of stibnite in the gravels) from the veins in the Matawai Valley. Terraces similar to these at the Waiau are found further south skirting the hills near the mouth of Awakanae Creek. The strip of sloping

alluvial country extending along the western base of Moehau is due partly to the union of the fans of the various high-grade streams scoring the flanks of the mountain-range, and partly to secular elevation of land.

The modern fluviatile deposits constitute the flood-plains of the various streams, and occupy the floors and embayments of their valleys. These deposits consist of waterworn detritus derived from the older rocks of the area, and are disposed as rudely stratified, false-bedded gravels and sands. Near the sea-margin this fluviatile material coalesces with the deposits of the littoral zone to form alluvial flats. The largest of these flats occur in the vicinity of Mercury Bay and Coromandel, and others of lesser extent at Whangapoua, Kennedy's Bay, Cabbage Bay, Manaia, and elsewhere.

Lacustrine Deposits.

Evidence of the existence, in the subdivision, of lacustrine deposits during Quaternary times, has been afforded only by mine operations. The shaft of the Kathleen Mine, Coromandel, was sunk 105 ft. through sands and muds before the andesitic rock was reached. The lower portion of this unconsolidated material, according to Maclaren, consisted of fine-grained blue and yellow clays containing leaf-impressions, and a shell of a Unio (*Unio menziesii*(?), Gray).* It would appear, therefore, that at least temporary lacustrine conditions prevailed in this old valley during Quaternary times.

Littoral Deposits.

The littoral zone is the zone between high- and low-water marks. The deposits occurring here consist of boulders, gravels, sands, and estuarine muds, the last-named being more characteristic of the sheltered inlets and the estuaries.

The older deposits coming under this heading consist of raised beaches and also certain estuarine deposits. The raised beaches, like the high-level river-terraces, are practically confined to the western side of the peninsula.

Remnants of these raised beaches are conspicuous at several places on the coast-line between Ongahi Creek and Waiaro Creek. A short distance to the north of the latter locality they attain a maximum elevation of 70 ft. above the present sea-level. Their existence further southward, at Torehine, at an elevation of 80 ft. has been reported by McKay.† On the eastern coast-line the only occurrence observed was at Opito, on the north-eastern extremity of the Kuaotunu Peninsula. There is here a bench of well-stratified marine shingle lying 8 ft. above high-water mark.

The older littoral or estuarine deposits are those at Coromandel, concerning which Maclaren‡ makes the following reference: "A shaft through recent alluvium was sunk in 1862–63 at a point to the right of the Huaroa Creek, near the main Coromandel–Thames Road. It reached a depth of 150 ft. through varying beds of sands, clays, and gravels. At 150 ft. an old 'sea-floor with mangrove-stumps' (in the words of the owner) was reached."

It would appear that alluvium, to a depth of from 100 ft. to 200 ft., extends from a point north of the Kathleen shaft (see estuarine deposits) to the vicinity of the landward margin of the hilly andesitic outlier forming Preece's Point Peninsula.

Littoral deposits, more recent in age than those described, form the beaches and mud-flats of the relatively great length of coast-line which girdles this portion of the Cape Colville Peninsula. Boulders and "shingle" are characteristic of the more exposed portions of the coast-line, especially those skirting areas in which massive igneous rocks abound. The extensive boulder beaches of the north-western shore-lines of the peninsula consist largely of the rocks which form the intrusives of Moehau Range. The set of the marine currents carries these well-rounded boulders even as far southward as Waiaro Creek, where they are piled up as great banks. A rougher coast-line is, however, that bordering an area in which heavy volcanic breccias and agglomerates predominate. The rough angular lava blocks, which constitute a great portion of these pyroclastic rocks, often stretch for miles along the seaboard between the tide-marks.

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* Maclaren: C.–9, 1900, p. 12. † McKay: C.–9, 1897, p. 70. ‡ Maclaren: C.–9, 1900, p. 12.

Sandy beaches fringe the exposed coast-line where the country is of low elevation. The sand is generally light in colour, and consists in the main of quartz. A concentration-product is the thin layers of " black sand," consisting mainly of magnetite, which occur in some places on these beaches. This " black sand " in the regions of auriferous rocks carries a little gold, but this never occurs in sufficient quantity to be of any economic value. With the ordinary light-coloured sands is frequently associated an abundance of comminuted marine shells. The most extensive sand beaches are on the eastern side of the peninsula, where those of the following localities may be mentioned: Cook's Bay ($1\frac{1}{4}$ miles), Mercury Bay (Buffalo Beach, 2 miles), Mahinapua (2 miles), Whangapoua ($2\frac{1}{2}$ miles), Te Pungapunga (1 mile), Kennedy's Bay ($1\frac{1}{4}$ miles), Matamataharakeke (1 mile), and Port Jackson (1 mile).

The finer littoral deposits are the muds of the estuaries and other sheltered coastal inlets. On the eastern coast-line, muds with sandy lenses form the spacious tidal flats and the small islets of the upper portions of Whitianga Estuary, and also similar features of lesser extent in the Purangi Estuary. Extensive tidal mud-flats lie in the rear of the long sandy Omaro Spit which forms the outer barrier of the Whangapoua Harbour. The spit itself is the result of the conflict between marine and fluviatile forces, whereby sediments have been deposited as a bar. The inlets of the western coast-line of the peninsula —Coromandel, Te Kouma, and Manaia Harbours, and Cabbage Bay—exhibit spacious mud-flats covered at high tide, but at low tide bare and incised by the narrow channels of the streams debouching into these inlets. Clumps of mangroves skirting the inner edges of these flats are not an uncommon feature, and assist in the reclamation of land, which in these localities is steadily progressing.

Talus and Wind-blown Deposits.

Talus-deposits occur on the slopes of some of the ridges, especially where these are bare or scantily covered with vegetation. This débris is largely due to the unequal expansion and contraction of the rocks attendant on alternate heating and cooling.

Sand-dunes are conspicuous on portions of the northern and eastern coast-lines of the peninsula. This coast-line is exposed to the full force of the easterly and north-easterly winds which sweep the Pacific Ocean, and here, as might be expected, surf beaches are common. On the low grounds these sand-dunes are piled up to a height of from 10 ft. to 50 ft. Swamps, lagoons, and old stream-loops are of common occurrence in the rear of these lines of dunes. These features are to be observed at Port Jackson, Waikawau Bay, Whangapoua, Kuaotunu, Otama, Mahinapua, Cook's Bay, Wigmore Bay, and elsewhere.

Earth-movements of Quaternary Times.

Considerable oscillations within Quaternary times are recorded in the distribution and vertical extent of the various deposits of débris considered in this chapter. A movement of depression, which probably took place in Pleistocene times, is indicated by the estuarine or littoral deposits which still exist at 120 ft. below the present sea-level in Coromandel on the western coast-line, and by the deep tidal estuaries extending far inland at Whitianga and Purangi on the opposite coast-line. This movement of depression was succeeded by a slow elevation of the land, especially along portions of the western shore. Old sea-beaches were here raised to the elevations at which their remnants are at present found, and the rivers were forced to excavate much of the alluvium they had deposited during the period of subsidence, thus giving rise to higher-level terraces along their banks.

CHAPTER VIII.

IGNEOUS ROCKS

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CONTENT.

THE igneous rocks described in this chapter comprise (*a*) a great pile of massive and pyroclastic volcanics, which were at different periods in the Tertiary era extruded upon a rugged denuded surface of older stratified rocks ; (*b*) intrusives—some of Tertiary age, which form dykes and sills in the several series of the basement sedimentaries, or which intersect the Tertiary volcanics ; others, probably referable to a Pre-Jurassic age, associated with the more ancient of the sedimentaries (the Tokatea Hill and Moehau Series).

Certain contemporaneous volcanics have already been described as forming an important part of the Tokatea Hill Series, and to these particular igneous rocks no further reference need be made in the present chapter.

The Tertiary volcanic rocks range in chemical character from acidic to semi-basic, and are the products of three distinct periods of volcanic activity. The intrusive igneous rocks do not admit of definite separation according to age, and have therefore been grouped together.

The igneous rocks have thus been considered under the following headings :—

(1.) Tertiary volcanic rocks of the " First Period."
(2.) Tertiary volcanic rocks of the " Second Period " (Beeson's Island Series).
(3.) Tertiary volcanic rocks of the " Third Period."
(4.) Intrusive rocks of various periods.

(1.) TERTIARY VOLCANIC ROCKS OF THE "FIRST PERIOD."

General Statement.

The Tertiary volcanic rocks of the " First Period " have greater areal extension and greater vertical range than the volcanics of either of the subsequent Tertiary periods. The rocks of this series are in character semi-basic or intermediate, and to a very minor extent acidic.

The acidic rocks, apparently the oldest of the series, are finely tufaceous and brecciated rhyolites, which are confined to one belt, having but a very limited extension.

The semi-basic rocks consist of andesitic and dacitic tuffs, breccias, agglomerates, and lavas, and are found comparatively fresh and in all stages of alteration and decomposition. The petrographical examination of numerous rock-sections of the less altered andesites and dacites indicates that there exist only a few definite lithological types, and that in general these types are closely related to each other. As might be expected, minor phases of variation are of common occurrence even in the same lava-flow. None of the lavas show vesicular structure.

There appears to be no distinct order of succession among the different semi-basic members of this great volcanic formation, and, owing to the absence of well-marked types and the persistent propylitic alteration and surface decomposition, it is difficult to establish the identity of a particular flow rock or of a breccia-bed even in two neighbouring areas.

These volcanic rocks are piled up in mountainous masses, giving to the greater portion of the area its elevated and rugged character. The usual land-forms characteristic of crateral vents are, however, never preserved, owing to extensive modification by agencies of subaerial erosion.

Age.

The most direct and satisfactory evidence bearing on the age of the volcanic rocks of the " First Period " is afforded by the fact that they have been extruded upon a highly denuded surface of folded Jurassic and Pre-Jurassic sedimentaries, and, in certain localities, upon remnants of the Torehine Series of Lower Eocene(?) age. Further, these volcanics are themselves unconformably overlain by those of the " Second Period " which, upon the evidence available, have been referred to a Miocene age. It is therefore probable that the eruptions which gave origin to the volcanic rocks of the " First Period " continued intermittently throughout Upper Eocene times, and came to an end in the Lower Miocene period.

The evidence is inconclusive as to whether or no the earliest Tertiary eruptions in this subdivison were those productive of the acidic rocks—rhyolites. These rocks, however, form a narrow belt which always directly overlies either the older sedimentaries, or certain isolated patches of the Torehine beds resting unconformably on these sedimentaries. They are themselves overlain and intruded by the andesitic rocks of this locality, and are therefore of earlier origin than a great portion, if not all, of the semi-basic rocks. These rhyolites are much older than those which will be later described as occurring in the south-eastern portion of the subdivision, or those which have considerable development on the plains in the neighbourhood of Waihi, beyond the limits of the area under review.

It is of interest to note that McKay found on the higher slopes of Karangahake Mountain, in the southern portion of the Hauraki Division, spherulitic rhyolites which were intimately associated with the older Tertiary andesites.*

These two occurrences at widely separated localities—Coromandel and Karangahake—may possibly represent contemporaneous extrusions, but the relationship of the rhyolites to the andesites at Karangahake has not been investigated.

* " Rocks of Cape Colville Peninsula," vol. i, 1905, p. 104 ; vol. ii, 1906, p. 35.

(A.) The Rhyolites.

Distribution.—Rhyolites constitute only a small proportion of the volcanic rocks of the "First Period." They have their greatest development on the flanks of the main range, within the valley of the Umangawha Stream, which drains into Cabbage Bay. At a distance of one-quarter of a mile south of Trigonometrical Station BD, this belt of rhyolites crosses the main divide at an elevation of about 1,700 ft., and further east appears in the valley of the Omoho Creek, which flows into Kennedy's Bay.

Structure, and Conditions of Eruption.—The rhyolites forming the narrow belt already described, overlie directly the older stratified rocks and the remnants of the younger Torehine Series.

The accumulation of the rhyolites under terrestrial conditions is evidenced by the mudstones with coaly partings, which are interposed between the basement beds of rhyolitic breccias and the Torehine strata in the Omoho Valley. These beds, constituting the lowest horizon of the rhyolitic effusives, are coarse breccias of rather dark colour, containing much shattered sedimentary rock and carbonaceous material, also occasional fragments of porphyritic dyke rocks.

The rhyolites are in many localities considerably altered, but it would appear that the greater part, if not the whole, of these rocks is fragmental. The pyroclastic character of the material is well exhibited on the exposed cliffs of the western side of the mountain divide, in the vicinity of Barney Creek (Umangawha Valley). The bedded fine-grained tuffs, which are well consolidated, here dip at low angles to the south-west. With these tuffs certain bands occur which show, in addition to brecciation, wavy flowage-lines, and may therefore be designated "flow breccias." The rhyolites of this locality are overlain and intruded by the andesitic rocks forming the crest of the range. Andesitic dykes intersecting the acid tuffs are also well exhibited in the lower gorge of the Omoho Creek.

Petrology.—The rhyolitic tuffs are in general fine-grained rocks of pinkish-grey colour, showing small patches of cream-coloured waxy material derived from the decomposition of orthoclase, and also rounded grains or bipyramids of quartz. Small, dark-coloured, angular fragments of argillite and grauwacke, scattered through the rock, are relatively abundant. Under the microscope a matrix of light-brownish colour, generally micro-felsitic but in places almost glassy, is observed. Orthoclase is much the most abundant phenocryst, and occurs as fairly perfect crystals and as fragments all more or less sericitised. Plagioclase feldspar, although much altered, is recognisable by its twinning lamellæ. Quartz occurs as irregular rounded and angular grains, or as bipyramidal crystals, and biotite is occasionally visible as ragged plates. Ochreous patches occur sparingly throughout the groundmass of the rock, and are probably due to the decomposition of secondary pyrite.

These tuffs occur in the Omoho Valley and at many localities in the Umangawha Valley. At the Rangatira Claim, about 20 chains west of Trigonometrical Station BD, the tuffs contain small black inclusions of pitchstone, otherwise they resemble those already described. Silicification and pyritisation of the rocks is, however, particularly noticeable at the latter locality.

An analysis of a sample of typical rhyolitic tuff from the Omoho Creek, which, however, unavoidably contains small inclusions of argillite, is as under:—

Silica (SiO_2)	69·30
Alumina (Al_2O_3)	13·92
Ferric oxide (Fe_2O_3)	0·48
Ferrous oxide (FeO)	2·81
Manganous oxide (MnO)	0·42
Lime (CaO)	2·17
Magnesia (MgO)	0·25
Potassium-oxide (K_2O)	3·79
Sodium-oxide (Na_2O)	1·44
Titanium-oxide (TiO_2)	0·18
Carbonic anhydride (CO_2)	2·56
Water and organic matter	2·40
Total	99·72

(B.) The Andesites and Dacites.

Distribution.

The andesites and dacites throughout the whole subdivision are rarely distinguishable megascopically from each other, and are closely related petrographically; they have therefore, for purposes of convenience, been considered together.

The effusives have but a minor development in the northern portion of the subdivision. Lavas and consolidated breccias form a small area, which includes the sharply conical peak (elevation, 2,898 ft.) immediately to the south-east of the main crest of Te Moehau Mountain. This isolated patch lies at the greatest height which effusive rocks attain in the whole subdivision, and points to the removal by denudation of much volcanic material from the surface of the old rocks in the surrounding area.

The main belt of the "First Period" volcanics is continuous from near the north-eastern corner of the Harataunga Survey District to the southern limits of the subdivision, but the boundaries, as the accompanying maps will indicate, are extremely irregular. The northern prolongation of this belt lies on the eastern side of the mountain divide, between the old sedimentaries which form the higher portion of the range and the volcanics of the "Second Period" which form the hilly coastal belts. To the north-east of Cabbage Bay the rocks under consideration attain the crest of the main range, and from here, except for the interposition of the small rhyolite belt already described, continue uninterruptedly southward along the drainage-divide to the Tokatea Saddle, where it gives place to the rocks of the Tokatea Hill Series. Southward from the locality named the volcanics again form the crest of the main range, and continue to and beyond the southern limits of the subdivision. A stretch of some two to three miles of the range, however, is dominated by the Castle Rock dyke, an intrusive in these volcanics (see page 92).

Both on the eastward and westward sides of the mountain divide, from the Cabbage Bay section of this range southward to the limits of the subdivision, the rocks of the "First Period" have considerable development. They form, with the exception of the sedimentary rocks already described, the whole of the main range, but seldom extend to the coast-line of the peninsula, as they are, over considerable stretches, flanked by the volcanic rocks of the "Second Period" (Beeson's Island Series). On the actual western coast-line they appear within the Coromandel Harbour in the vicinity of Kevin Point and Preece's Point, while on the eastern coast-line they are exposed in the rear of Matamata-harakeke Beach, and near the margin of Whangapoua Harbour.

Structure, and Conditions of Eruption.

The andesites and dacites of the "First Period" overlie the folded Jurassic and Pre-Jurassic sedimentaries, and were extruded upon a surface of very irregular relief, as proven by the great disparity in the elevations of neighbouring areas of the old rocks underlying the extrusives.

These volcanics consist of tuffs, breccias, and lava-flows, the pyroclastic rocks on the whole predominating. The nature of these materials and their disposition, so far as this is determinable, are such as would lead to the conclusion that they have been extruded from a number of vents. The actual locality of any of these vents or foci of eruption is not apparent, owing to the great alteration of the rocks and the extensive denudation that has taken place since this period of eruptive activity. It is probable that some of the earliest eruptions were submarine, but there are clear evidences of the terrestrial conditions under which a great part of the volcanic accumulations was extruded. From the areal distribution of the volcanic rocks, and the prevailing north-and-south strike of the larger intrusive belts, it is probable that the vents or foci of eruption were disposed in a general meridional alignment. This would imply that fissuring of the sedimentary rocks, or zones of weakness, were induced parallel to the strike of the major folds, and that vents which were the centres of more or less intense volcanic activity existed at irregular intervals along these lines. There is apparently no definite order of succession among the different semi-basic members of this formation, it being difficult to identify a particular flow rock or breccia-bed even in two neighbouring localities. By far the greater portion

of the main belt of the volcanic rocks occurring within the Harataunga Survey District is fragmental, more especially in the lower horizons, but flows and also intrusives are not uncommon.

Within the Coromandel Survey District one of the best sections on the eastern side of the main divide is that taken from a point some 20 chains south of Trigonometrical Station UU, on the crest of the main range, across the Waikoromiko and Kopurukaitai Valleys. The rock here occupying the lowest position in the section, and overlying the Tokatea Hill Series, is a heavy flow of grey porphyritic hornblende andesite ; this is overlain by a flow of dark basaltic-looking andesite, which forms the principal rock of the Four-in-Hand Mine, and is itself overlain by heavy beds of tuffs and breccias. The whole series dips in an easterly direction, and represents a thickness exceeding 2,000 ft.

Within the Coromandel Valley mining operations have afforded some interesting information. The rocks of the Kapanga and Scotty's Mines, situated near the western base of Tokatea Hill, are fine-grained tuffs interstratified with solid flows of andesite and dacite. The Kapanga shaft (with a collar-elevation of 240 ft. above sea-level) has been sunk to a depth of 1,000 ft., and from the bottom of the shaft a borehole has been put down a further distance of 225 ft. The final 500 ft. to 600 ft. of this total distance of 1,225 ft. was sunk entirely through tuff beds, which dip at low angles to the west or south-west. At a depth of 940 ft. from the surface, or about 700 ft. below sea-level, a coal-seam, considerably silicified and pyritised, having the same disposition as the tuffs mentioned, was encountered. This band of coaly material, over 2 ft. in thickness, not only indicates a considerable period of quiescence between successive eruptions, but is cogent evidence of a considerable depression of this portion of the area subsequent to or contemporaneous with the eruptions which were productive of the upper 940 ft. of the accumulations. Several carbonaceous seams may be mentioned as occurring within and near the Triumph mining area, about a mile and a quarter further north than the Kapanga Mine. Since the bedded tuffs of the Kapanga Mine rise gradually towards the north—that is, in the direction of the Triumph Mine—it is quite possible that some connection exists between the carbonaceous deposits of the two areas, and therefore that these indicate one and the same old land-surface.

Within the area of the Hauraki group of mines, north of Kevin Point, on the shore-line of Coromandel Harbour, the rocks are in great part highly altered flow andesites, but here, as at the Preece's Point Peninsula some 70 chains to the southward, fragmental rocks also exist. Andesitic tuffs constitute the main mass of the country rock of the Success Mine and other mines in its vicinity on the western flank of the main range south of Kaipawa Mountain Below the Success Mine the road-cuttings, at an elevation of 590 ft., expose the tuffs and breccias resting on the highly inclined sedimentaries of the Tokatea Hill Series. At one point a remnant of lacustrine beds is seen lying in a small depression on the ancient land-surface. The lacustrine deposits consist of fine argillitic conglomerates or pebble-beds with thin mudstone partings, and a coal-seam of some 6 in. in thickness.

In the lower portions of the Waiau River Valley, flows of dark basaltic-looking andesite directly overlie the sedimentary rocks, but at higher elevations in this valley andesitic breccias predominate. Some of these breccias have a peculiar conglomeratic appearance, as if a portion of the extrusive fragmental material had been affected by fluviatile agencies prior to consolidation and envelopment by the products of later eruptions.

In the area further south, an east-and-west sectional line drawn from the middle course of the Taurarahi Stream (Manaia Valley) on the western side of the divide, to the junction of the Waitakatanga and Mahakirau Streams on the eastern side of the divide, lies wholly within these rocks. This line measures over five miles in length, and crosses the divide at an elevation of about 1,300 ft. The actual disposition of the rock on the western side of the divide is not apparent. From the point of contact of the volcanics with the Manaia Hill Series in the Taurarahi Creek, to the crest of the range, massive andesite, in all stages of alteration, occurs. On the eastern slopes of the range tuffs and breccias with minor flows of andesite form the volcanic pile, the whole series having a general dip at low angles to the eastward. The ancient foci of eruption here may, in position, correspond approximately with the highest points of the mountain divide.

The general disposition of these " First Period " volcanics with reference to the older and younger rocks of the area is shown in the sectional maps accompanying this report.

Petrology.

Megascopic Characters.—In appearance the freshest specimens of the massive andesites and dacites are usually dark-coloured, dense, and finely porphyritic, showing small scattered glistening phenocrysts of plagioclase feldspar. Less frequently, owing to the greater abundance of phenocrysts, of which plagioclase is the most important, the rocks are lighter-coloured and assume various shades of grey. A greenish tinge, which is due to the presence of chlorite and other secondary minerals, is of general occurrence. The rocks occurring in certain relatively large areas are highly propylitised, and in many of the mine-workings present the appearance of a whitish kaolin-like mass, in which little more than secondary pyrite can be readily identified. All stages of gradation exist between these light-coloured highly propylitised rocks and the dark-coloured comparatively fresh rocks.

The andesitic tuffs, breccias, and agglomerates are well consolidated, particularly those of the lower horizons, which constitute the ejectamenta of the earlier eruptions. Owing to the greater permeability of these fragmentals they are invariably altered to a considerable extent. In the case of the older accumulations the larger fragments are no better preserved than the fine cementing material, and the original nature of the rock is difficult to determine. Certain of the later breccias, however, afford fragments of fairly fresh massive rocks, and these are always identical with those occurring as lava-flows or intrusives. These volcanic fragmentals are normally of whitish, light-grey, or greenish-grey colour; the most abundant types appear to be breccias, consisting in the main of angular fragments ranging from 2 in. to 4 in. in their largest dimensions. Within the propylitic areas the tuffs and breccias are altered to a light-coloured kaolin-like mass, frequently not to be distinguished from the propylitic stage of the massive rocks. The appearance and nature of the weathered products of these pyroclastic rocks are in general the same as those of the massive andesites and dacites already described.

The andesites and dacites are very prone to surface weathering, and are very frequently covered to a considerable depth with the débris resulting from their decomposition and disintegration. This material is coloured various shades of red, brown, and yellow, due in great measure to hydrated ferric oxides. The tendency of many of the massive flow rocks and the solid inclusions in the breccias to weather spheroidally is an interesting phenomenon, and cores of hard fresh rock encased in concentric exfoliating layers are of frequent occurrence. As already indicated, the different types of andesitic and dacitic rocks of the "First Period" are rarely distinguishable from each other megascopically, and this statement is more particularly true of the finer-textured varieties, which constitute by far the greater bulk of the volcanics. While microscopic examination admits of the separation of these rocks into several types, according to the dominant ferro-magnesian constituent, the petrographical structure of the rocks in general and the nature of the several mineral constituents may be considered irrespectively of the separate types.

Structure of the Matrix.—Two distinct types of matrix or groundmass, as well as a third of somewhat general character, are recognisable. The first two types are the hyalopilitic and the micropœcilitic (pilotaxitic), as defined by Sollas. The latter is far more common that the former, which is characteristic of only a minor percentage of the "First Period" rocks. The third type is the microcrystalline or finely granular groundmass, and is, next to the micropœcilitic, the one of most frequent occurrence.

In respect to the hyalopilitic and pilotaxitic(?) matrices of the Hauraki andesites and dacites, Professor Sollas, who has examined a great number of the rocks, remarks:—

"The nature of the matrix in the andesites and dacites offered a very difficult problem, and one of some importance, since in many cases the matrix contributes one-half to the bulk of the rocks. Rosenbusch clearly perceived the obvious existence of two types, which he distinguished as hyalopilitic and pilotaxitic. The first presents no difficulty; in it the mineral constituents of the rock, felspar laths, and the like, are immersed in a glassy base. The second is more obscure, and was defined by Rosenbusch as consisting entirely of a felt of microliths or minute crystals. I have never seen such a matrix in this class of rock. As a matter of fact, the second type of matrix differs from the first in this: that the glass of the hyalopilitic matrix is replaced by a mosaic of crystalline grains, which, by reason partly of their irregular jagged outlines, partly of the similarity of their refraction index to that of the felspar

microliths, are very difficult to diagnose, especially when, as frequently happens, they are very minute. When the structure is coarser, however, they may be plainly recognised as quartz, a conclusion long ago reached by Williams and Iddings, and one which I can completely confirm by the decisive observations that when, as in the dacites, primary grains of obvious quartz are present, the mineral forming the pilotaxitic mosaic surrounding them can be traced into optical continuity with these grains. Thus the glass of the hyalopilitic matrix is represented in a number of definitely ascertained cases by the quartz of the pilotaxitic matrix. Williams and Iddings have given the name ' micropœcillitic ' to such a pilotaxitic structure, and this term may in most cases be substituted for ' pilotaxitic ' wherever the latter occurs in my report. It does not follow, however, that the pilotaxitic structure is invariably an expression of micropœcillitic quartz ; some other mineral might conceivably play the same part as quartz. A second species of felspar might do so, and though this may be regarded as improbable, yet its possibility must be borne in mind ; and since descriptions should, as far as possible, express facts, and not hypotheses, I may here state that whenever I have used the word ' pilotaxitic ' in this report it must be taken simply to indicate that the glass of the hyalopilitic matrix is replaced by a crystalline substance forming mosaics.

" It will be seen from this that the andesites are divided from the dacites by a very narrow line ; both contain quartz. Rosenbusch has proposed to distinguish the dacites by the presence of quartz as a phenocryst, but Zirkel points out that many rocks which, as proved by analysis, are true dacites do not possess such primary grains of quartz. No doubt the presence of primary grains of quartz is a sure indication that we are dealing with a dacite, but their absence does not prove the contrary, and thus there are numerous cases where the application of the name ' dacite ' or ' andesite ' must depend on the judgment of the observer. Chemical analysis can be the only court of ultimate appeal in such cases."*

Throughout vol. ii of " Rocks of Cape Colville Peninsula," Professor Sollas substituted the term " micropœcillitic " for " pilotaxitic," which was used in vol. i. In the present bulletin the term " micropœcillitic " has been used with the signification expressed in the above quotation. In order to avoid tedious repetition of these adjectival terms in the subsequent descriptions, (m.) placed after the word " andesite " or " dacite " will signify " micropœcilitic " ; (h.) will signify " hyalopilitic."

The andesites and dacites having a micro-crystalline, finely crystalline, or finely granular matrix, show gradations towards their hypabyssal equivalents, the porphyrites.

General Character of the Phenocrysts.—The plagioclase feldspars, the most abundant constituents porphyritically developed in all the andesites, generally range from andesine to labradorite. The more acid types, albite and oligoclase, and the more basic, anorthite, are, however, occasionally present, the specific gravities determined by Sollas having an extreme range from 2·59 to 2·78. It cannot be affirmed that the more acid or the more basic plagioclase characterizes any particular type of rock, and the possibility of the presence of the whole series—albite to anorthite—in a single specimen of an hypersthene andesite (from Preece's Point, Coromandel) is reported by Sollas.† The general habit, the zoning, the twinning, and the inclusions which characterize the plagioclase phenocrysts of andesitic rocks are all exhibited in those occurring in the particular rocks under consideration. Orthoclase is of very rare occurrence in these effusives, although it is sometimes present in the porphyrites and diorites. Carbonates and sericite are the usual alteration-products of the feldspar, while pseudomorphs of chlorite are also very common.

Hypersthene, using the term in its wider signification to include the lighter-coloured variety enstatite, is by far the most commonly occurring ferro-magnesian constituent of these andesites. It not only forms the characteristic mineral of a very common rock-type, but is an important subsidiary mineral in almost all the other groups. Under the microscope the crystals vary in ordinary light from colourless to reddish brown, those of the more pronounced colour exhibiting the deeper pleochroism. The most common alteration-products are a greenish fibrous serpentine, which is generally disposed along fractures or cleavage-cracks, and chlorite, which is formed under somewhat

* " Rocks of Cape Colville Peninsula," vol. i, 1905, p. 118. † *Loc. cit.*, vol. i, 1905, p. 134.

similar conditions. The usual replacement pseudomorphs are carbonates and chlorite, with occasionally quartz, epidote, and a greenish biotite.

Augite rarely occurs as the dominant ferro-magnesian constituent, but, in association with an approximately equal amount of hypersthene, constitutes the pyroxene andesites of the classification adopted. The mineral, which is colourless or greenish grey with occasionally faint pleochroism, takes the form of single crystals or of clusters of crystals, the latter often showing irregular intergrowths with hypersthene. The crystals, which often show rounded edges, are on the whole smaller than those of hypersthene. The alteration products are similar to those of the rhombic pyroxenes. Uralitisation has not been detected in the case of the augite of the effusive rocks, although occurring in their hypabyssal analogues.

Hornblende is of much less frequent occurrence than either the rhombic or monoclinic pyroxenes in the volcanics of the "First Period," and, as might be expected, is more characteristic of the dacites than of the andesites. This mineral is not as stable as the pyroxenes, and is generally recognisable only by the outlines of its pseudomorphs. When fresh the hornblende is strongly pleochroic, varying in colour from yellowish-brown or sage-green to faint straw-yellow, and exhibiting dark reaction borders. The extinction angles range up to 20°. Pseudomorphic products consist of finely comminuted magnetite, minute pyroxene granules, chlorite, carbonates, quartz, hydrated ferric oxides, and leucoxene.

Quartz, as a primary constituent determining the dacitic type of rock, is always very sparsely distributed. It occurs either as medium-sized rounded grains, which are often corroded by the matrix, or as small angular grains in the interstitial material. Small bipyramidal crystals have also been observed.

Other primary mineral constituents present are magnetite, ilmenite, zircon, and apatite. The original iron-ores, magnetite and ilmenite, occur as fairly large crystals or small granules, and are often of considerable abundance. The presence of titanium-oxide (TiO_2) to the extent of 0·6 to 0·9 per cent. in the rocks is indicated by all the analyses. The titaniferous minerals give rise to the alteration-product leucoxene. Small zircons, together with needles and minute crystals of apatite, are sparingly distributed throughout some of the rocks.

Olivine might be expected to occur, considering the preponderance of pyroxene-bearing andesites, but its presence has not yet been detected.

Primary biotite is singularly absent from the volcanic rocks of this period, though occurring abundantly in some of the diorites and porphyrites of the Moehau area.

Secondary products already mentioned are carbonates, sericite, chlorite (most common variety, pennine), fibrous serpentine, quartz, epidote, greenish biotite, magnetite, leucoxene, and hydrated ferric oxides. The biotite occurs only to a small extent, and generally in connection with complex pseudomorphs replacing ferro-magnesian minerals. Rutile and sphene are even more rare constituents of the same pseudomorphs. Pyrite is a common secondary mineral, especially in those volcanics which have been subjected to propylitisation. (See page 75.)

Types of the Volcanic Rocks of the "First Period."—The following types of volcanic rocks may be established :—

(*a.*) Hypersthene andesites : Andesites, with hypersthene the dominant ferro-magnesian constituent.

(*b.*) Augite andesites : Andesites, with augite the dominant ferro-magnesian constituent.

(*c.*) Pyroxene andesites : Andesites, with pyroxenes (rhombic and monoclinic, in approximately equal association) the dominant ferro-magnesian constituents.

(*d.*) Hornblende andesites : Andesites, in which hornblende is the dominant ferro-magnesian constituent.

(*e.*) Dacites : Rocks of andesitic type, in which quartz occurs as phenocrysts.

Between the four first-named types there exists every gradation, and the position therefore of certain rocks in the classification adopted rests largely on the judgment of the observer. Thus, hypersthene andesite occurs in which hornblende, though a subordinate ferro-magnesian constituent,

is relatively abundant ; this has been termed hornblende hypersthene andesite ; similarly hypersthene hornblende andesite may be distinguished, and the line of demarcation between these two varieties must in certain cases be an arbitrary one.

The dacites are, like the andesites, separable into several varieties according to the dominant ferro-magnesian constituents. These rocks, however, have in general such close mineralogical affinities with the andesites that they are often very doubtfully distinguishable from them.

(*a.*) *Hypersthene Andesites.*—Hypersthene andesite, using the term to cover also the several varieties of this rock, is apparently the most widely spread type of the " First Period " semi-basic volcanics. It is, furthermore, the type of greatest economic importance, in that it constitutes the whole or the major portion of the country rock of many of the principal mining claims.

A fairly typical specimen is that which occurs, both comparatively fresh and in all stages of alteration, in the Four-in-Hand Mine, Waikoromiko. When fresh this is a compact dark basalt-like rock, in which small phenocrysts of feldspar and ferro-magnesian minerals are recognisable megascopically. Under the microscope the groundmass, which constitutes more than half the rock, is micropœcilitic with numerous rectangular feldspar laths, minute pyroxenes, and magnetite. Flow structure is fairly conspicuous. The phenocrystic plagioclase is of the usual andesitic character, the extinction angles indicating a range from andes ne to labradorite ; hypersthene, as elongated prisms and aggregates, is, of course, the dominant ferro-magnesian mineral, and shows considerable alteration to chlorite and to a green serpentinous mineral. Aug te is present to a much lesser extent than the rhombic pyroxene. A few fairly large scattered grains of magnetite occur.

As secondary minerals, pyrite, sericite, carbonates, quartz, and epidote are all present in greater or lesser amount, according to the stage of alteration of the rock.

An analysis of a sample of this hypersthene andesite, taken from the Four-in-Hand low-level crosscut, is as follows :—

Silica (SiO_2)	55·58
Alumina (Al_2O_3)	17·27
Ferric oxide (Fe_2O_3)	1·12
Ferrous oxide (FeO)	7·41
Manganous oxide (MnO)	0·40
Lime (CaO)	7·30
Magnesia (MgO)	4·85
Potassium-oxide (K_2O)	0·46
Sodium-oxide (Na_2O)	1·50
Titanium-oxide (TiO_2)	0·67
Carbonic anhydride (CO_2)	1·45
Water and organic matter	2·05
Total	100·06

This hypersthene andesite appears to extend eastward from the headwaters of the Waikoromiko Creek, and forms the greater part of the spur between this stream and the Kopurukaitai. This is the spur upon which the Four-in-Hand Mine is situated. A similar rock, though considerably altered, appears in the Mangatu Creek, which, like the Waikoromiko and Kopurukaitai, is a tributary of the Harataunga, draining into Kennedy's Bay.

A fairly fresh hypersthene andesite (m.) containing a little augite, forms Trigonometrical Station UU, on the crest of the main divide. Further northward in Austral Hill is seen an hypersthene andesite having what seems to be a remnant of glass in the matrix (hyalopilitic ?), also a few sparsely scattered hornblende phenocrysts. In Matamataharakeke Creek, about four miles to the north-east of Austral Hill, is found an altered rock somewhat akin to the andesite last described.

Within the watershed draining into the Coromandel Harbour, hypersthene andesites are of very general occurrence. They have been described by Sollas and McKay, from the Britannia Mine, near the western base of Tokatea Hill ; from Preece's Point, near its north-western extremity ; and from

the Bunker's Hill Claim, at the quarry on the foreshore of Coromandel Harbour. That from Preece's Point is a typical hypersthene andesite, but is rather remarkable as containing possibly the whole range of plagioclases from albite to anorthite. That from Bunker's Hill Claim contains, as subsidiary ferro-magnesian minerals, both hornblende and augite. Certain other rocks collected were designated "pyroxene andesites," owing to alteration processes having rendered the original nature of the pyroxenes doubtful. Regarding one of these "pyroxene andesites" from the Kapanga Mine, at a depth of 1,200 ft. from the surface or 960 ft. below sea-level, Sollas remarks, "The outlines of some [of the pseudomorphs] suggest hypersthene" * It is therefore likely that the rock should appear with the hypersthene andesites of the present classification. Further south, in the main southerly headwater branch of the Waiau River, is found a hornblende hypersthene andesite having a remnant of glassy base; this rock contains a rather unusual amount of secondary carbonates in mosaic-like patches.

On the eastern side of the main divide hypersthene andesites (m.) are described by Sollas and McKay from Blackstone Creek, Opitonui Creek, and the Maiden Mine—all in the main Whangapoua Valley. Further south, in the watershed of the Mahakirau River, similar rocks were collected and determined by the writers, from Waitakatanga Creek, Rocky Creek, and Sparrow Creek; they doubtless form a great part of the altered rock of the Mahakirau Valley.

(*b.*) *Augite Andesites.*—Andesites of the "First Period," in which augite is the dominant ferro-magnesian constituent, are rare. Of the many microscopic sections made by the writers only two could be designated "augite andesite," while none have been reported by Sollas and McKay from the Coromandel subdivision.

One of the two rocks referred by the writers to this type was taken from the cutting of the Coromandel–Cabbage Bay Road, at the head of Whaiwango (Big Paul's) Creek. Megascopically it is a dark finely textured rock, with a few small glistening feldspar phenocrysts. Under the microscope the groundmass is micropœcilitic of the usual character, and constitutes about half the rock. The phenocrysts are plagioclase of the labradorite type, augite in considerable abundance showing much lamellar twinning, and magnetite as scattered cubes and grains.

The locus of the other specimen mentioned is a cutting in the vicinity of the Maiden Mine, Opitonui, and the rock is an obscurely micropœcilitic augite andesite with a little hypersthene. As, however, hypersthene andesites occur largely in the same vicinity, this augite andesite may be only a phase of the former more commonly occurring type.

An analysis of this augite andesite from near the Maiden Mine is as under :—

Silica (SiO_2)	53·28
Alumina (Al_2O_3)	17·54
Ferric oxide (Fe_2O_3)	1·20
Ferrous oxide (FeO)	7·92
Manganous oxide (MnO)	0·78
Lime (CaO)	7·70
Magnesia (MgO)	5·26
Potassium-oxide (K_2O)	0·26
Sodium-oxide (Na_2O)	2·01
Titanium-oxide (TiO_2)	[illegible]·61
Carbonic anhydride (CO_2)	1·24
Water and organic matter	[illegible]·08
Total	99·88

(*c.*) *Pyroxene Andesites.*—The andesites, in which monoclinic and rhombic pyroxenes in approximately equal proportion constitute the dominant ferro-magnesian minerals, are of common occurrence. Their general megascopic and microscopic characters differ in no respect from those of the types

* "Rocks of Cape Colville Peninsula," vol. i, 1905, p. 165.

already described. In none of the specimens from the various localities to be cited was a hyalopilitic groundmass observed, although in some sections the groundmass might be termed obscurely micropœcilitic—that is, only slightly differentiated from isotropic or glassy material.

On the eastern side of the divide pyroxene andesite (m.) forms the solid spheroidal cores of the altered rock enclosing the " Silver Lode " in Tangiaro Creek, Port Charles. A similar rock, and also rocks with finely crystalline groundmasses, appear, further south, to form a large part of the volcanics incised by Waikawau Creek and its main confluent the Waikanae.

Within the Kennedy's Bay watershed a dark basalt-like pyroxene andesite occurs in the valley of the left branch of the Kopurukaitai Creek, about 30 chains above the main fork, and also near the Four-in-Hand battery; this rock probably represents only a slight differentiation of the upper part of the hypersthene andesite lava-flow, which forms the main mass of the spur between the Kopurukaitai and Waikoromiko Creeks. Within the valleys of the southern tributaries of the Harataunga, dark fine-textured pyroxene andesites (m.) occur near the heads of the Mataiterangi and Wairakau Creeks. The pyroxene andesites of the Mangatu Creek contain a little hornblende, while a specimen collected from the Omoho Creek, about 60 chains from the Harataunga junction, shows this mineral as small sharply outlined crystals, in sufficient quantity to warrant the rock being termed a hornblende pyroxene andesite.

Within the Whangapoua Valley certain decomposed andesites (m.) obtained from the Waitekuri Stream may perhaps be grouped with this type, although the pyroxenes in these rocks are not abundant nor are they sufficiently well preserved to enable their specific character to be determined. Further south in the Mahakirau Valley the type is represented in the andesite of the middle course of Rocky Creek.

On the western side of the divide certain rocks from the Britannia and Kapanga North Mines (Coromandel) have been designated by Sollas* " pyroxene andesites," evidently on account of the pseudomorphic products obscuring the original character of the pyroxenes.

South of Coromandel a fine-grained greenish-black rock with minute shimmering phenocrysts is seen in the road-cuttings a short distance west of the Opitonui Saddle. The pyroxenes are considerably altered, but apparently both the rhombic and the monoclinic types are equally abundant.

Remnants of fine-grained dark andesite occur in the much-altered rock of the road-cuttings in the Waiau Valley within 14 chains of the saddle; this rock proves to be an obscurely micropœcilitic pyroxene andesite. The type is also represented in the inclusions of massive rock in the breccias of the Awakanae Creek and further south in the head of the Tupa Creek, a tributary of the Manaia River. Both these rocks have a micropœcilitic matrix, and that from the Tupa shows among the phenocrysts a few small crystals of hornblende.

(*d.*) *Hornblende Andesites.*—The effusive hornblende andesites of the " First Period " are confined to a few localities, and have close affinities with the hornblende dacites, which are of rather more general occurrence.

The best-defined belt of hornblende andesite is that extending from the Harataunga Stream up the valley of the Waikoromiko Creek. The rock is in general light grey and rather coarsely porphyritic, but shades into a darker finer-textured variety. Under the microscope the light-grey rock is seen to have a finely crystalline groundmass, consisting in the main of feldspar with a few minute hornblendes. Secondary quartz is present and occasionally, possibly, a little primary quartz. The darker fine-grained rock shows a micropœcilitic matrix, and occasionally exhibits flow structure. The phenocrysts of plagioclase are in general considerably altered to carbonates and sericite, or are replaced by pseudomorphs of chlorite. Greenish to dark-brown hornblende, with resorption borders, is conspicuous as prismatic individuals and aggregates, but is often considerably altered. Hypersthene and augite occur to a very minor extent, also magnetite, ilmenite, and their secondary products. Pyrite in small cubes and irregular grains is disseminated sparsely throughout the rock. Some of these rocks might well be designated " porphyrite " or " andesite porphyry," did not the field evidence suggest that they constitute lava-flows rather than intrusive masses.

* Sollas and McKay: " Rocks of Cape Colville Peninsula," vol. ii, 1905, pp. 141, 144.

On the same (eastern) side of the main divide hornblende andesite is found in the headwaters of the Waitakatanga Valley, forming a great part of the included fragments of the altered pyroclastic rocks into which has been intruded the Castle Rock dyke.

On the western side of the divide the dark fine-grained rock overlying the old sedimentaries at Pa Hill, Tiki, is a hypersthene hornblende andesite (m.). The same rock appears to have considerable development among the altered volcanics of the low grounds of the Tiki and Waiau Valleys.

Among the many altered andesites of the Coromandel mining centre it is highly probable that some had hornblende dominant, but identifiable rocks of this type among those classed as "First Period" volcanics have not been detected in the area.

An analysis of a typical hornblende andesite from the Waikoromiko Creek is as under :—

Silica (SiO_2)	57·25
Alumina (Al_2O_3)	16·39
Ferric oxide (Fe_2O_3)	0·40
Ferrous oxide (FeO)	7·35
Manganous oxide (MnO)	0·36
Lime (CaO)	4·50
Magnesia (MgO)	3·55
Potassium-oxide (K_2O)	1·97
Sodium-oxide (Na_2O)	2·37
Titanium-oxide (TiO_2)	0·92
Carbonic anhydride (CO_2)	1·38
Water and organic matter	3·25
Total	99·69

(*e.*) *Dacites.*—The dacites are, as already indicated, often separable from the andesites only with difficulty. Almost all of the volcanics of the "First Period" from the Coromandel subdivision, which were classed as dacites by Professor Sollas, and also those which have been determined as dacites by the writers of this bulletin, show considerable alteration. As dacites in a comparatively fresh state seldom or never occur, the primary nature of much of the quartz-content in the altered rocks may be open to question. In general appearance and in structure the rocks differ in no respect from the normal andesites of similar states of alteration, except in the presence of recognisable free quartz.

Within the watershed draining into Coromandel Harbour, certain rocks from the following mines have been pronounced dacitic by Professor Sollas :—

Scotty's Mine—

(*a.*) From underground workings : Light-grey decomposed pyritised rock ; altered dacite with hornblende.

(*b.*) From a depth of 250 ft. in mine : Bluish-grey felstone-like rock ; altered dacite.

Britannia Mine—

(*a.*) From workings : Light-grey (brecciated) fine-grained, pyritised rock ; altered dacite (or andesite).

(*b.*) Bluish-grey felstone-looking rock with obvious feldspar crystals ; altered dacite with hornblende.

(*c.*) Greenish brecciated pyritised rock ; dacite or andesite.

Success Mine—

(*a.*) Upper level : Dark greenish-grey felstone-like rock ; dacite.

(*b.*) Low level : Greenish-grey compact pyritised rock ; a much-altered hornblende dacite or andesite.

Kathleen Mine—

(*a.*) 150 ft. to 200 ft. from surface: Greenish-grey decomposed porphyritic rock; altered dacite.

(*b.*) 150 ft. to 200 ft. from surface: An obviously decomposed rock; altered hornblende dacite or dacite porphyrite.

Hauraki Mine—

From an unascertained locality in the mine-workings: Grey to black basaltic-looking rock, with large crystals of feldspar scattered porphyritically; altered hornblende dacite or dacite porphyrite.

A dark-greenish-coloured rock was collected by the writers from Whangarahi Creek (not far from the Britannia Mine, where the occurrence of dacites has been mentioned). Under the microscope this rock is seen to have a micropœcilitic groundmass. The plagioclase phenocrysts are of the usual andesitic character, but are in general considerably altered to calcite and sericite. Quartz occurs both as rounded grains (which may be primary) and mosaics (probably secondary). The pyroxenes are represented only by pseudomorphs. The rock can only be termed an altered dacite or andesite, but, as no even moderately fresh sample was procurable, this doubtful rock was submitted for chemical analysis. The appended result shows a silica-percentage much too low for a dacite, and, even having regard to the considerable alteration evidenced by the quantity of carbonates present, the rock should more consistently be classed with the andesites.

Silica (SiO_2)	48·90
Alumina (Al_2O_3)	17·67
Ferric oxide (Fe_2O_3)	1·20
Ferrous oxide (FeO)	7·06
Manganous oxide (MnO)	0·19
Lime (CaO)	11·00
Magnesia (MgO)	3·91
Potassium-oxide (K_2O)	0·34
Sodium-oxide (Na_2O)	1·89
Titanium-oxide (TiO_2)	0·98
Carbonic anhydride (CO_2)	4·87
Water and organic matter	2·28
Total	100·29

Dacites have been identified from localities further south than these mentioned, but all are in a similarly altered condition. At the head of the main left branch of the Tiki Creek a hornblende dacite occurs, and in Bremner's tunnel, at the head of the Matawai Creek, the altered porphyritic rock proves to be a much-altered dacite or dacite porphyrite.

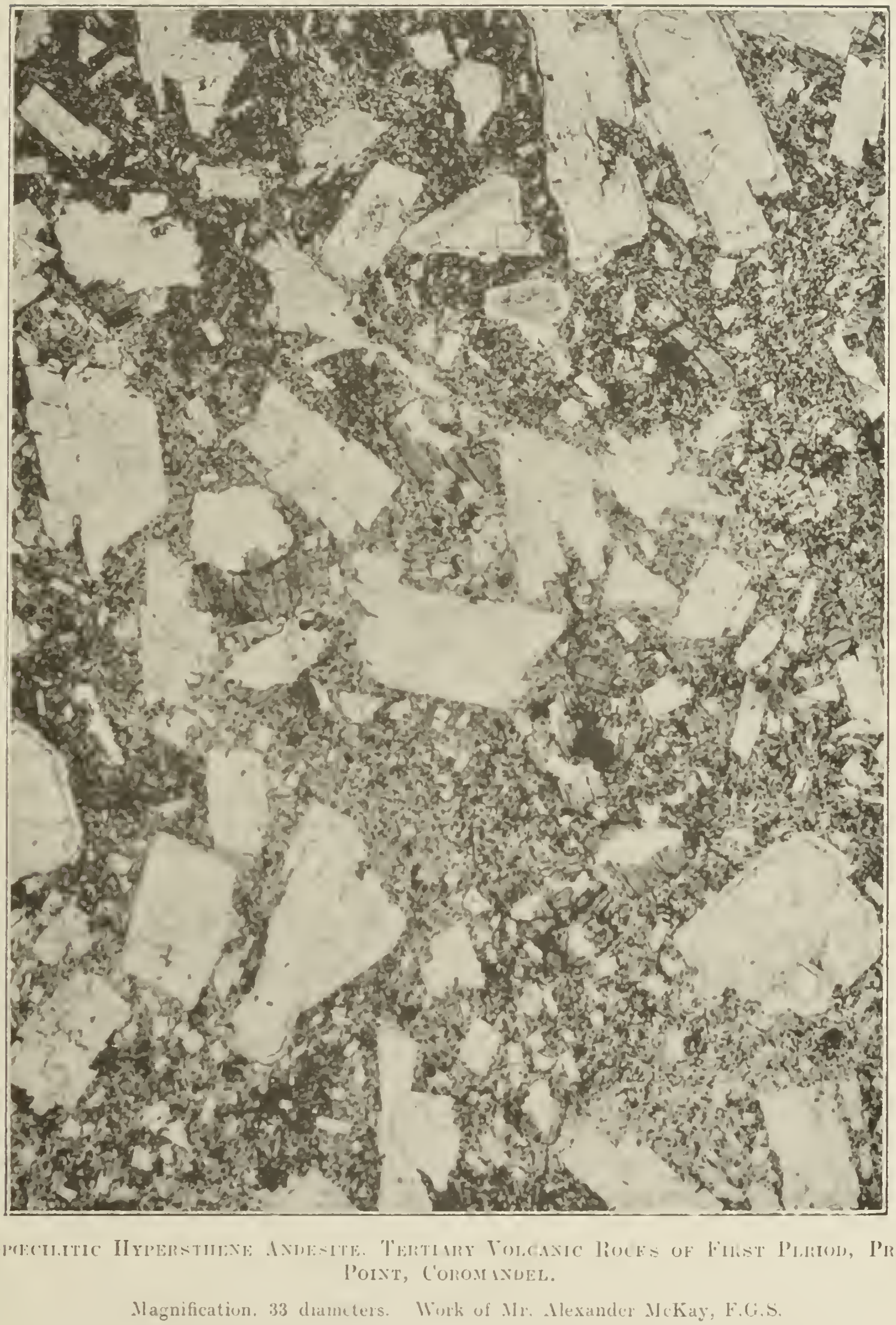
On the eastern side of the main divide dacitic rocks occur in the Whareroa and Omoho Creeks, and much further south a hornblende dacite was identified from Battery Creek, Mahakirau Valley.

Propylitisation of the Volcanic Rocks.

A very general alteration of the andesites and dacites is a characteristic feature of the vein-bearing areas of the subdivision. This alteration is best described as "propylitisation," the term being used to indicate the changes superinduced in andesites and similar rocks by solfataric action, which result in the formation of "propylite" as defined by Rosenbusch.

The highly propylitised rocks, or propylites, have a white, greyish-white, or bluish-white colour, and a rather granular or earthy appearance. Opaque white pseudomorphs of feldspar and traces of ferro-magnesian minerals are sometimes observable, the former giving to the rock a rather spotted

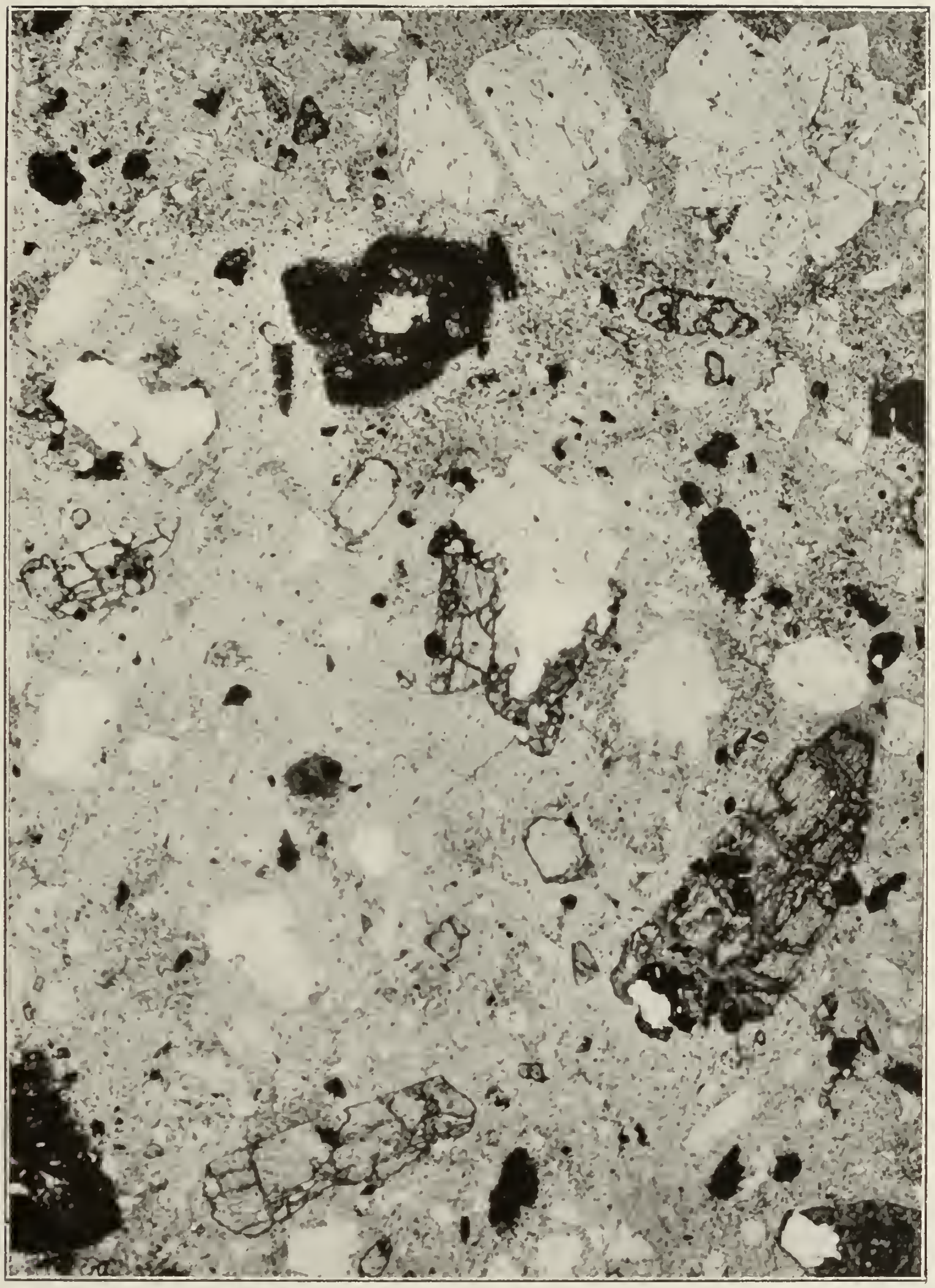
PLATE XX.



MICROPŒCILITIC HYPERSTHENE ANDESITE. TERTIARY VOLCANIC ROCKS OF FIRST PERIOD, PREECE'S POINT, COROMANDEL.

Magnification, 33 diameters. Work of Mr. Alexander McKay, F.G.S.

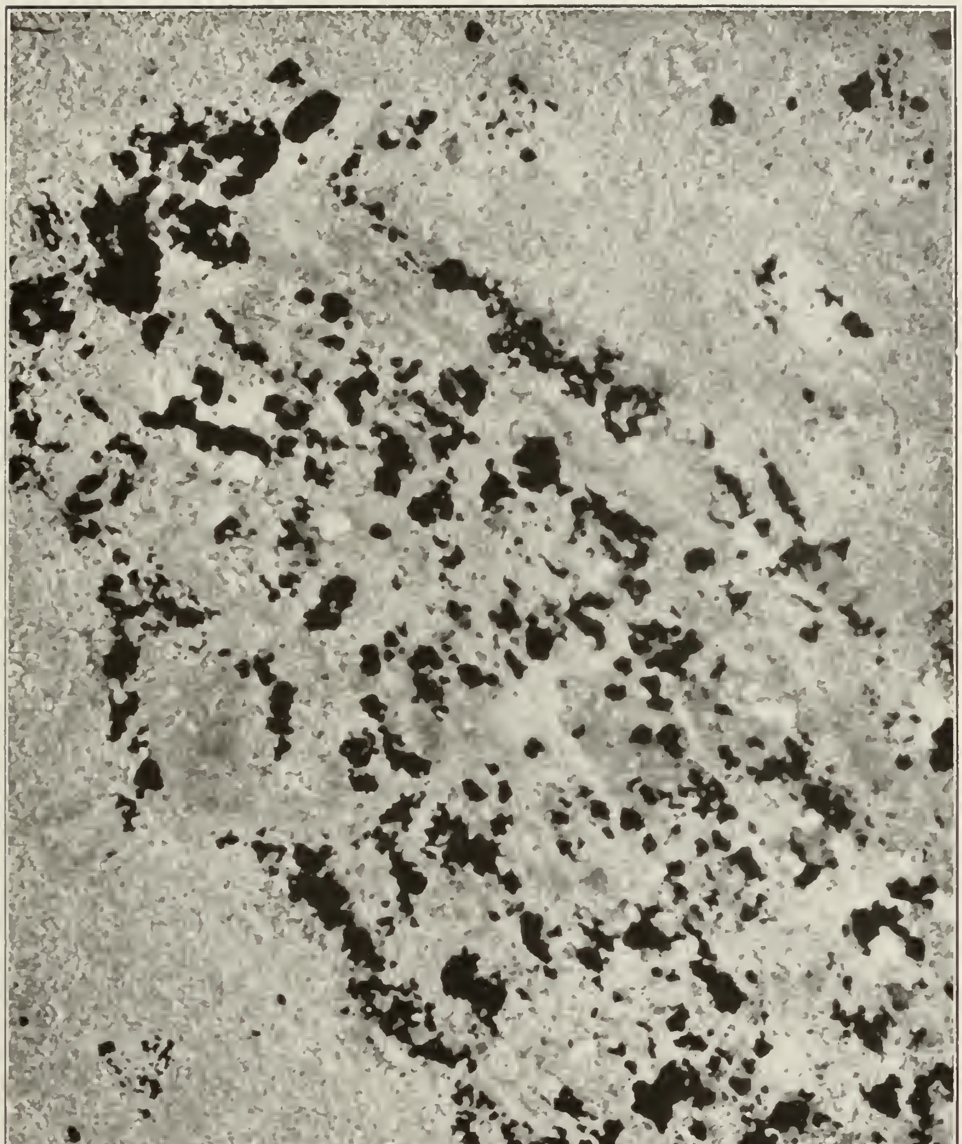
PLATE XXI.



Microprœcilitic Hypersthene Hornblende Andesite, Tertiary Volcanic Rocks of First Period, Pa Hill, Tiki.

Magnification, 33 diameters. Work of Mr. Alexander McKay, F.G.S.

PLATE XXII.



Propylitised Andesite, Tertiary Volcanic Rocks of First Period, Hauraki Mine, Coromandel.

Magnification, 33 diameters. Work of Mr. Alexander McKay, F.G.S.

appearance. Pyrite is fairly abundant, and as a rule the further the propylitisation has progressed the greater is the amount of this mineral present.

Under the microscope the feldspars are seen to be replaced by calcite, sericite, and quartz, and are sometimes impregnated with chlorite. The ferro-magnesian silicates are altogether dispersed, or their outlines are preserved by alteration products—chlorite, sericite, carbonates, quartz, and very rarely epidote. Pyrite is often present with the pseudomorphs after ferro-magnesian minerals, in addition to occurring as cubes and irregular grains throughout the rock generally.

It seems likely that both silica and carbon-dioxide were introduced by the agencies of thermal metamorphism during the periods of vein-formation, and it is quite certain that the ascendng waters or gases were sulphur-bearing. The amount of pyrite (the bisulphide of iron) present in the propylitic areas is relatively very great, whereas the mineral is altogether absent from the unaltered rocks. The frequent occurrence of pyrite within the pseudomorphs after ferro-magnesian silicates, suggests that the pyrite was formed by the action of the sulphur-bearing waters on the iron of the original minerals. Plate XXII (page 74) is fairly representative of the propylitised andesites and dacites under the microscope, and shows pyrite occurring within the area formerly occupied by the ferro-magnesian mineral.

. According to Rosenbusch, " The characteristic feature of the propylitic facies consists in the loss of the glassy habit of the feldspars ; in the chloritic alteration of the hornblende, biotite, and pyroxene (often with an intermediate stage of uralite), with simultaneous development of epidote ; further, in alteration of the normal groundmass into holocrystalline granular aggregates of feldspar, quartz, chlorite, epidote(?), and calcite, and in a considerable development of sulphides (usually pyrite)."*

Inasmuch as the formation of epidote is not characteristic of the thermal metamorphism of the Coromandel andesites, the term " propylitic " is in this bulletin employed in a rather more general sense than that postulated by Rosenbusch.

(2.) TERTIARY VOLCANIC ROCKS OF THE "SECOND PERIOD" (BEESON'S ISLAND SERIES).

General Statement.

The Tertiary volcanic rocks of the " Second Period " consist entirely of andesitic and dacitic tuffs, breccias, agglomerates, and lavas. With these effusive rocks are associated numerous dykes of andesite and porphyrite, which in places, however, cannot be distinguished from the lava-flows. Where the intrusive nature of these rocks is apparent they have been especially mapped, and are considered in a later portion of this chapter. The effusive rocks form essentially coastal belts on both sides of the peninsula. Some of the belts are of considerable extent transverse to the trend of the peninsula, and in places exceed 1,000 ft. in elevation, but never attain the crest of the mountain divide.

In general, the fragmental rocks of the Beeson's Island Series are less well consolidated, and the lavas less decomposed and also less crystalline than those of the " First Period."

A Miocene age has been assigned to the eruptive rocks under review, for reasons which will be hereafter stated. The term " Beeson's Island Series," as applying to these rocks, is well established, and is used as an alternative to " Tertiary volcanic rocks of the ' Second Period ' " in the present bulletin. Beeson's Island, where these rocks have their typical development, lies on the northern side of the entrance to Coromandel Harbour.

It should be here remarked that where these rocks flank and overlie those of the " First Period," the actual contact of the two series is frequently by no means apparent. On account of a general similarity in original composition of the earlier and later andesites, the question of determining a boundary often baffles solution, even when field-work is supplemented by microscopic study. The tracing of a connection between a doubtful phase and some characteristic phase in the rock-mass has, however, frequently allowed of a boundary being placed fairly approximately.

* " Element der Gesteinslehre," Stuttgart, 1898, p. 302.

Age and Correlation.

The volcanic rocks of the "Second Period" or Beeson's Island Series were, in 1883, referred to the Miocene period by Cox, who remarked that the breccia-beds at Beeson's Island and certain other localities "are the same as those . . . . occurring at the Manukau Heads." In respect to the latter locality, which lies some fifty-five miles to the eastward of the Cape Colville Peninsula, Cox remarks that "the heavy angular volcanic breccias, which are regularly stratified, lie quite conformably on certain glauconitic sandstones, which pass down into the Waitemata marls as developed at Manukau Harbour." The Waitemata beds have been, on palæontological evidence, assigned to the Lower Miocene period, and include interstratified persistent beds of volcanic (andesitic) grits, which have been the subject of several geological notices and reports.* These andesitic grits occurring in definitely ascertained Miocene strata are sure proof of considerable eruptive activity in Miocene times. It is therefore reasonable to infer, even apart from any lithological resemblances of the pyroclastic material at Beeson's Island and Manukau Heads, that the manifestations of vulcanism were not confined to the Waitemata-Manukau area, but must be held to account for part of the Tertiary andesitic complex of the Hauraki Peninsula.

No proofs of the actual age of the Beeson's Island Series were observed within the Coromandel subdivision, but their unconformable superposition on the volcanics of the "First Period" is apparent. On the eastern side of the divide the dark glassy lavas and the heavy breccia-beds are found within the Kopurukaitai Valley overlying the highly propylitic andesites of the "First Period," and the abrupt termination of detrital gold in the stream-beds immediately the younger rocks are reached is very noticeable. On the western side of the divide, a section taken from the coast-line near Torehine to the crest of the main divide near Austral Hill is suggestive of the removal by denudation of a considerable mass of the older volcanics before the younger accumulations were extruded, and therefore indicates unconformity between the two series. McKay, who has previously noted this, writes as follows: "At Cabbage Bay this unconformity [of the Beeson's Island Series] to the rocks of the Kapanga (older) group is most marked. The rocks of the latter group had been removed from the middle and lower valley of the Umangawha and the slates laid bare before the commencement of the igneous outbursts, as a result of which the Beeson's Island rocks were deposited." †

Park deduces the age of the "Second Period" volcanics from leaf-impressions obtained from the shales with thin coaly partings, which at certain places in the Hauraki Division occur at the base of the series. The localities Paparoa and Cabbage Bay (within the subdivision), where prospecting for coal was some years ago prosecuted, are mentioned among others. Concerning the various widely separated occurrences, this geologist remarks, "At all places they [the shales] contain numerous leaf-impressions and fragments of carbonised wood. The most characteristic plant-impressions are those of *Dacrydinium cupressinum*, *Dacrydium* sp.(?), and *Podocarpium*, which indicate a Miocene age for the volcanic rocks, with which they are associated." ‡

In this bulletin, from consideration of the facts cited above, a Miocene age has been ascribed to the volcanics of the "Second Period" (Beeson's Island Series).

Distribution.

As already indicated, the effusive rocks of the "Second Period" or Beeson's Island Series constitute coastal belts on both sides of the peninsula.

On the eastern coast-line a small area of breccias and agglomerates forms the conspicuous north-eastern headland near Sugar Loaf Rocks, this being the most northerly occurrence of these volcanics. Further to the southward rocks of this group, consisting mainly of coarse breccias, form comparatively

* Hochstetter, F. von: "Reise der 'Novara': Geology," i, p. 34. Hutton, F. W.: Trans., vol. xvii, 1884, p. 307. Cox, S. H.: Reps. N.Z.G.S., vol. xiii, 1881, pp. 17, 25; vol. xiv, 1882, p. 27. Hector, J.: Reps. N.Z.G.S., vol. xiii, 1879–80. McKay, A.: Reps. N.Z.G.S., vol. xvi, 1883–84, p. 102. Park, J.: Reps. N.Z.G.S., 1885, vol. xvii, p. 158. Mulgan, E. K.: Trans., vol. xxxiv, 1901, p. 414. Fox, C. E.: Trans., vol. xxxiv, 1901, p. 452.

† C.–9, 1897, p. 63.

‡ Park, J.: "Geology and Veins of the Hauraki Goldfields," 1897, p. 36.

extensive coastal belts of hilly country. These have extension from Stony Bay to Waikawau Creek, from south-east of Matamataharakeke Beach to the north-eastern shores of Kennedy's Bay, and from the southern shores of Kennedy's Bay to Whangapoua Harbour.

Much the largest area of these volcanics is that covering a great part of the Kuaotunu Peninsula and the hilly country lying to the north and west of the large alluvial flats of the Mercury Bay settlement. The western boundary of this area is a sinuous line extending southward from the shores of Whangapoua Harbour, near the mouth of Opitonui Creek, to a point near the junction of the Waitakatanga and Mahakirau Streams. From this stream-junction the boundary continues in a southerly and then an easterly direction to the southern limits of the district.

On the western side of the peninsula these rocks are not found further north than Cabbage Bay. They form the greater part of the range lying between the Umangawha Stream, Cabbage Bay, and the western coast-line, and, as a gradually narrowing belt, extend southward to the headwaters of Paparoa Creek. At a point on the coast-line some half a mile to the north of Paparoa Creek another coastal belt commences, overlying at Paparoa the rocks of the Manaia Hill Series. This narrow belt, excepting that it is concealed in two or three places by Recent fluviatile deposits, is continuous in a south-easterly direction to Kikowhakarere; from here it extends in a south and south-westerly direction, forming Dacre Hills and finally the Ruffin Peninsula on the north side of Coromandel Harbour. Separated from this peninsula by a narrow tidal passage is Beeson's Island, the typical locality of the rocks of this series. On the mainland to the south of Beeson's Island the hilly country lying between the southern shore-line of Coromandel Harbour and Manaia Harbour, and deeply indented by Te Kouma Harbour, consists entirely of fragmental rocks of the Beeson's Island Series; so also does the greater portion of the area lying between the southern shore-line of Manaia Harbour and the southern boundary of the subdivision. Numerous small islands lying off the stretch of coast-line between Cabbage Bay and Manaia belong to this rock-formation.

Structure, and Conditions of Eruption.

The extrusives of the "Second Period" consist in the main of irregularly stratified pyroclastic rocks, with which are associated at greater or lesser intervals intercalated lava-flows. Less frequently, however, the massive rocks are found forming almost exclusively relatively large areas. The pyroclastic rocks consist of fine clayey tuffs, sandy tuffs, sandy tuffs interspersed with lapilli, fine and coarse breccias, agglomerates, and all gradations between these more or less definite types. Certain natural sections afforded by the cliffs of the coast-line show bedding-planes with some degree of regularity, other exposures show considerable thickness of pyroclastic material without any perceptible arrangement.

The earliest eruptions of this period were probably submarine, but there are abundant evidences, as will be cited later, of the subaerial conditions under which a great part of the volcanic materials was extruded. The predominant paroxysmal character of these eruptions along both coast-lines of the peninsula would appear to be explainable on the assumption that sea-water had frequent and ready access to the vents. The fact is particularly noticeable that the massive rocks of this series have their greatest development in those portions of the larger areas which are furthest removed from the sea-coast. Lavas are, for instance, much more abundant than fragmental rocks in that portion of the Kuaotunu Peninsula Range which approaches nearest to the main Cape Colville Range.

On the western side of the peninsula the rocks forming the hilly coastal belts, which are brokenly continuous from Cabbage Bay to the southern boundary of the subdivision, consist in the main of fragmental material. The disposition of the irregularly stratified beds suggests that the principal foci of eruption lay to the west of the present coast-line. In this connection the existence of the chains of islands of similar formation lying off the coast-line is significant. In the extreme south-west corner of the subdivision, however, the persistent dip of the beds seaward from the sharp peak Pukewhakatara-tara (1,293 ft.), and the frequent occurrence here of very heavy lava-blocks, indicate the locus of a major explosive centre in the vicinity of this peak. The heavy agglomerates and the steeply inclined

columnar lava-streams of the outward extremity of Ruffin Peninsula also suggest that this is probably the locality of one of the minor vents.

One of the most interesting and instructive sections on the western side of the peninsula is that exposed near the south headland of Cabbage Bay.* The rocks here are agglomerates, coarse and fine breccias, and sandy and clayey tuffs. Two or three old land-surfaces, on which grew a luxuriant vegetation, are traceable within these bedded fragmentals. On one of these old surfaces roots and stumps of trees, the latter ranging up to 2 ft. in diameter, are found in their natural positions, the roots in the soil and trunks broken off a short distance above the ground-level. Heavy showers of ejectamenta, the products of eruption from an adjacent subaerial volcano, devastated and overwhelmed this ancient forested land, and have formed the coarse and finer grained breccias which surround and overlie the remnants of this forest. All of this vegetable material has been completely carbonised or silicified; and considerable quantities of fossil wood may be seen strewn along the adjacent sea-beaches.

At the head of the middle branch of the Paparoa Creek prospecting operations have revealed the presence of two thin erratically disposed seams of coal, enclosed in greasy slickensided shales, which evidently mark the base of the volcanic series. The greatest thickness of coal discovered was about 4 in.

On the coast-line north of Paparoa Creek heavy flows of dark-grey porphyritic andesite occur, but, between the creek named and Koputauaki, pyroclastic rocks consisting of both coarse and fine materials predominate, and enclose occasional fragments of silicified wood. These beds dip in general to the north-east—that is, in a direction away from the present sea-border.

Flows of glassy andesite, tuffs and breccias, and dyke rocks, characterize the area lying between Kikowhakarere and Long Bay, and extending inland 30 to 80 chains. Similar rocks occur also in the continuation of this area as the narrow hilly peninsula which terminates at the Little Passage.

Beeson's Island and the coastal area extending from the south side of the Coromandel Harbour to the southern limits of the subdivision show a marked similarity in structure. The accumulations consist almost entirely of pyroclastic rocks, showing in many places a rude stratification. In addition to the usual phases of tuffs, breccias, and agglomerates, agglomeratic accumulations were observed, consisting entirely of black angular lava-blocks varying from larger to smaller dimensions without any fine cementing-material. These blocks are held together by their "slaggy" exterior surfaces, which therefore were evidently plastic at the time when the ejectamenta reached their present position. Lava flows and dykes are rare occurrences in this particular area.

Maclaren has, on the disposition of the pyroclastics, assumed the existence of a crater between the north headland of Te Kouma Harbour and Rangipukea Island, near the main entrance of Coromandel Harbour.† This hypothesis is further supported by the soundings as shown on the chart of this locality.

On the small peninsula lying between the Manaia and Te Kouma Harbours dome-shaped hillocks are rather conspicuous features (Plate XXIII). The flanks of these hillocks show in places vertical rock-faces, well exhibiting the structure of the mass. Sandy light-coloured tuffs, which weather easily, form beds capped by bands of dark-coloured heavy agglomerates. The latter, owing to the resistance offered to weathering agencies, form a capping which overhangs somewhat the lower vertical walls of tufaceous material.

On the north-eastern coast-line the small area forming the Sugar Loaf Headland shows all the pyroclastic rocks typical of the series, with brecciated lava-flows forming resistant buttresses. This is evidently a northerly remnant of the larger area, which has its present northerly termination on the south shore of Stony Bay. A very small patch of breccias is still preserved on the northern headland of the bay named.

Between Stony Bay and Port Charles the rocks consist in the main of coarse and fine breccias, with here and there intercalated flows of dark andesite. Nests and irregular veinlets of calcite are not uncommon in the finer fragmental material.

The Port Charles Peninsula, together with the area northward of a line drawn due east from the junction of Tangiaro and Eel Creeks, to the outer coast-line is of interest, as the localities or near vici-

* This section has been described by McKay—C.-9, 1897, p. 60. † C-9, 1900, p. 10.

PLATE XXIII

Hillocks of Stratified Tuffs and Agglomerates (Beeson's Island Series), between Te Kouma and Manaia Harbours.

Stratified Tuffs and Agglomerates (Beeson's Island Series), forming Hills between Te Kouma and Manaia Harbours.

PLATE XXIV.

Te Kouma Harbour.

Trigonometrical Station RR, Kennedy's Bay. (Peak consists of Andesitic Breccias.)

nities of several centres of eruption appear to be suggested by the character and disposition of the accumulations. One of these craters probably existed to the north of Carey's Bay, another in the vicinity of the "Hanging Rock" to the south-east of the inner reach of Port Charles Inlet, while a minor one has been exposed by marine erosion on the outer coast-line some 85 chains south-east of the main northern headland. Almost all the volcanic products in these areas are pyroclastic, and include fragments of carbonised and silicified wood; a massive columnar andesite, however, forms the prominent buttress of the northern headland.

The continuation of this hilly coastal belt from Port Charles to Matamataharakeke Beach shows in the main similar pyroclastic material, with lava-streams and dyke rocks, the beds in general having a dip seaward. Silicified wood is not uncommon in the breccias, often as tree-trunks a foot or more in diameter. Further southward the coastal belt extending from Haupapa Point to Kennedy's Bay consists of rocks characteristic of the series. The pyroclastics greatly predominate, and the beds have a prevailing dip to the eastward. The northern coast-line of Kennedy's Bay exhibits breccias overlying a massive grey lava-stream. These breccias weather in a variety of fantastic shapes, due largely to their fissured and cavernous nature. The more secluded of the caves they contain have been used as places of sepulture by the Maoris.

The Kennedy's Bay – Whangapoua belt is not less characteristic of the rocks of the series than those already described. The boundary-line between these andesites of the Beeson's Island type and the andesites of the "First Period" is apparent in certain of the eastern branches of Kopurukaitai Stream. The comparatively fresh, dark, basalt-like lava-streams of the later period are in places found overlying the light-coloured highly propylitic rocks of the older group. The resistance which the breccias and agglomerates of the "Second Period" frequently offer to weathering agencies is well exemplified in the existence of the bold peak which constitutes Trigonometrical Station RR (1,024 ft.) near Kennedy's Bay (Plate XXIV). The sharp outlines of this peak suggest the existence here of a dyke rock rather than the pyroclastic material of which it is actually composed.

The Kuaotunu Peninsula and the continuation of this area south-westward to the Mahakirau Valley consist in greater part of fragmental and massive rocks, which are in the main typical of the Beeson's Island Series, and have, therefore, all been referred to the "Second Period." The rocks on the lower hilly volcanic country of the northern side of the Kuaotunu Peninsula are in general very much decomposed. Eastward from the alluvial flats of the Opitonui Stream the weathered products are moderately characteristic of the series under description; but an examination of the section afforded by the upper course of the Mapauriki Creek establishes the identity of the breccias existing here with those of typical areas of "Second Period" rocks.

The section afforded by the Coromandel–Kuaotunu Road, passing north-eastward from the crossing of Mapauriki Creek to the coast-line at Materangi Bluff and from here eastward for about a mile, is instructive; fine-grained andesitic and dacitic tuffs, breccias, and lava-flows, dipping in general to the south-eastward, alternate rapidly with one another, and present the general colorations and characters typical of rocks of this series. About half a mile south of this coast-line is the conspicuous sharp peak of Te Tutu (636 ft.), the most undoubted old volcanic crater yet located on the Hauraki Peninsula. A slip on the south-east side of the hill has exposed the old pipe or crateral vent, filled with agglomerate composed mainly of blocks of black glassy andesite. The walls of this pipe consist of consolidated fine tufaceous rock of lighter colour than the agglomerate neck.

The outer end of the peninsula consists in the main of pyroclastic rocks, with intercalated flows of porphyritic andesite or dacite. The pyroclastics are in no way distinguishable from those at Manaia or Beeson's Island. Even the peculiar dome-shaped hillocks described as occurring at Manaia are paralleled in the area between Stewart Creek and Matapaua Bay. In the western portion of the Kuaotunu area massive rocks form most of the higher country drained by the Opitonui, Owera, Taputapu, and Wade Creeks. Near the contact between the Beeson's Island Series and the volcanics of the "First Period," breccias and fine stratified tuffs occur. With these fine stratified sandy tuffs in Hooker Creek, and in the main left-hand branch of the Waitakatanga Creek, are associated coaly shales and very small seams of impure coal. The boundary-line between the two volcanic series here and north to Whangapoua Harbour is, as might be expected, a very intricate one, and can be mapped only approximately

Petrology.

Megascopic Characters.—The Tertiary volcanics of the " Second Period," as stated before, consist of tuffs, breccias, agglomerates, and lavas, and with these are associated intrusives not always distinguishable from the lava-flows. The pyroclastics are much more abundant than the lavas. The tuffs and breccias in general resemble those of the " First Period," but are on the whole less well consolidated.

Included fragments of massive rocks in the breccias and agglomerates are often comparatively fresh, whereas in the fragmentals of the " First Period " they are often in as poor a state of preservation as the softer matrix. The tuffs are generally light-coloured, and vary in texture from a fine clayey to a gritty, sandy mass. Such fragmental beds of fairly uniform character are well exhibited in the vicinity of Manaia Harbour and Kirita Bay. The breccias and agglomerates are in colour light-grey, purplish to dark grey, or almost black, the finer matrix generally showing the lighter colours. The included fragments are sometimes sparsely distributed throughout a tufaceous, rapidly weathering matrix, or again constitute by far the greater bulk of the rock, while occasionally (see page 78) heavy lava-blocks and rubbly angular fragments without matrix constitute the whole rock-mass. A rather less common type of these pyroclastics is that encountered on the coast-line of the Port Charles Peninsula and at the extremity of Kuaotunu Peninsula. The white ashy matrix of certain breccias in these localities is speckled with fairly large perfect or fractured idiomorphic crystals of hornblende. It would appear certain that these crystals must have been contained in a fluid matrix before expulsion from the crater. These peculiar fragmental rocks recall the " crystal tuffs " of certain writers.

The massive rocks vary in colour from light grey to black. On the whole the groundmass has a more lithoidal, glassy appearance, and the hornblende or hypersthene phenocrysts are perhaps more conspicuous than in the great majority of the rocks of the " First Period."

The lighter-coloured massive rocks and included fragments of the pyroclastics present, on weathering, surfaces which are rough and prickly to the touch. This fact led to the rocks of the Beeson's Island Series being denominated trachytes by the early writers on the district, prior to the general introduction of petrographical methods for rock-determination. The surface débris representing the disintegrated and completely weathered rocks, even more so than in the case of the older volcanics, is characterized by variegated colorations of red, brown, and yellow, due largely to hydrated ferric oxides. Many of the areas of the " Second Period " rocks, as, for example, the outer part of Kuaotunu Peninsula or the Manaia and Te Kouma headlands, present a decidedly barren appearance, and little or no soil overlies the disintegrated rock.

Propylitic alteration of the " Second Period " volcanics is confined in the main to certain areas of the south-eastern part of the subdivision, and these and other minor areas will receive further reference in connection with the quartz veins.

Character of the Matrix, and Phenocrysts.—The different types of matrix described in connection with the volcanics of the " First Period " are also those which mark the rocks at present under consideration. The hyalopilitic type, however, which was of very infrequent occurrence in the rocks of the older series, here becomes the most characteristic, whereas in a great many rocks the matrix is what may be termed obscurely micropœcilitic. In addition to the types mentioned, the microcrystalline and finely crystalline groundmasses are also represented. The phenocrysts and their alteration-products are the same as those detailed in connection with the older volcanics. The types of plagioclases of the most common occurrence are andesine and an acid type of labradorite. The crystals are often very well preserved, and are on the whole much fresher than in the older rocks ; but they frequently show corrosion by the glassy groundmass, and contain inclusions of dirty-brownish glass, sometimes arranged zonally.

Of the ferro-magnesian minerals hypersthene is again the most abundant ; augite is a common constituent, but is rarely dominant ; hornblende is on the whole much better preserved than in the older rocks, and is of more widespread occurrence.

Quartz as a phenocryst is rarely present, and appears to constitute only a sporadic constituent. As in the " First Period " volcanics, a poor demarcation between the andesites and dacites therefore obtains in this series.

Types of Volcanic Rocks of the "Second Period."—The volcanic rocks of the "Second Period," on the classification adopted in this bulletin, are separable into the following types :—

(*a.*) Hypersthene andesites.
(*b.*) Pyroxene andesites.
(*c.*) Hornblende andesites.
(*d.*) Dacites.

No hard and fast line, however, separates one type from another, and the position of certain rocks in the classification depends largely on the judgment of the observer.

(*a.*) *Hypersthene Andesite.* — Hypersthene andesite constitutes the predominant type of the "Second Period" volcanics. The following tabulation sets forth the localities from which the several varieties of this rock have been determined, either by Sollas and McKay or by the writers :—

Hyalopilitic hypersthene andesites occur at—

Sugar Loaf Headland : As inclusions, of trachytoid appearance, in breccia.

Kerr Creek (Port Charles) : As dull lithoidal rocks, forming the lava-flows and perhaps dyke, between the head of the creek and the coast-line.

Waikawau–Whangapoua coastal belt : Forming a great part of the breccias and lava-streams of the coast-line.

Te Tutu Volcanic Neck, Materangi Ridge and Bluffs : Constituting lavas, tuffs, breccias, and agglomerates.

Mahakirau River : As lava-flows, one mile east of the junction with Waitakatanga Creek.

Cabbage Bay – Kikowhakarere coastal belt : As pyroclastic and massive rocks, occasionally containing a little hornblende.

Beeson's Island, Ruffin Peninsula, and Te Kouma – Manaia areas : Forming apparently the greater part of the pyroclastic and massive rocks ; a little hornblende is occasionally present.

Micropœcilitic hypersthene andesites occur at—

Sandy Bay : As basaltic-looking rock in coastal breccias.

Port Charles Headland : As a columnar lava-stream forming main outer headland ; this basaltic-looking rock contains sufficient hornblende to admit of it being termed a hornblende hypersthene andesite.

Waikawau–Whangapoua coastal belt : As trachytoid and basaltic-looking rocks forming breccias and lava-streams.

Owera Mine (Whangapoua) : As the only fairly fresh rock obtainable in the locality ; this lava contains a few minute crystals of hornblende. The propylitic weathered rock here resembles that of the mine-workings at Materangi and Murphy's Hill rather than the andesites of the "First Period" at the Opitonui Mine.

Materangi Bluff : As a basalt-like rock, containing a little hornblende and augite.

Kuaotunu – Mercury Bay Road : As a somewhat weathered rock, occurring at Brown's Camp between the Try Fluke Mine and the main saddle.

South coast-line of Kuaotunu Peninsula, near the mouth of Whauwhau Creek : As rather coarse, porphyritic, massive, and pyroclastic rocks—hornblende hypersthene andesites.

Cabbage Bay to Kikowhakarere coastal belt, and its continuation forming Ruffin Peninsula : Associated with the rocks, having a glassy or hyalopilitic groundmass.

Special mention should be made in respect to one of these andesites occurring within the Waikawau-Whangapoua coastal belt. The exact locality is the south-west shore-line of Kennedy's Bay, where the breccias afford fragments of one of the most singular volcanic rocks of the whole subdivision. Sollas, who has determined the specimen as a hornblende hypersthene andesite, pronounces it a "flow breccia." The phenocrysts are "brecciated and displaced in a remarkable fashion, ... having been reduced to small angular fragments, which have been carried along with the flow and distributed in stream-lines, thus giving rise to lenticular streaks in which feldspar predominates, since, as usual,

it was the most abundant phenocryst in the rock." "This example," he adds, "proves the need for caution when referring brecciation to subsequent movements of consolidated rock. The present case might easily be mistaken for one of 'mylonitisation.'"* In the hand-specimen this flow brecciation gives to the rock a peculiar schistose appearance

A typical hyalopilitic hypersthene andesite, containing an occasional crystal of decomposing hornblende, was collected from the outer end of Beeson's Island, and on analysis gave the following result :—

Silica (SiO_2)	57·68
Alumina (Al_2O_3)	18·84
Ferric oxide (Fe_2O_3)	4·96
Ferrous oxide (FeO)	1·44
Manganous oxide (MnO)	0 21
Lime (CaO)	6 05
Magnesia (MgO)	4·00
Potassium-oxide (K_2O)	2·15
Sodium-oxide (Na_2O)	2·16
Titanium-oxide (TiO_2)	0·82
Carbonic anhydride (CO_2)	0·75
Water and organic matter	0·90
Total	99·96

The chemical analysis of an andesite from the breccia-beds at Long Bay, Ruffin Peninsula, may here be submitted. (Owing, unfortunately, to the loss of the hand-specimen collected the rock was not petrographically determined.)

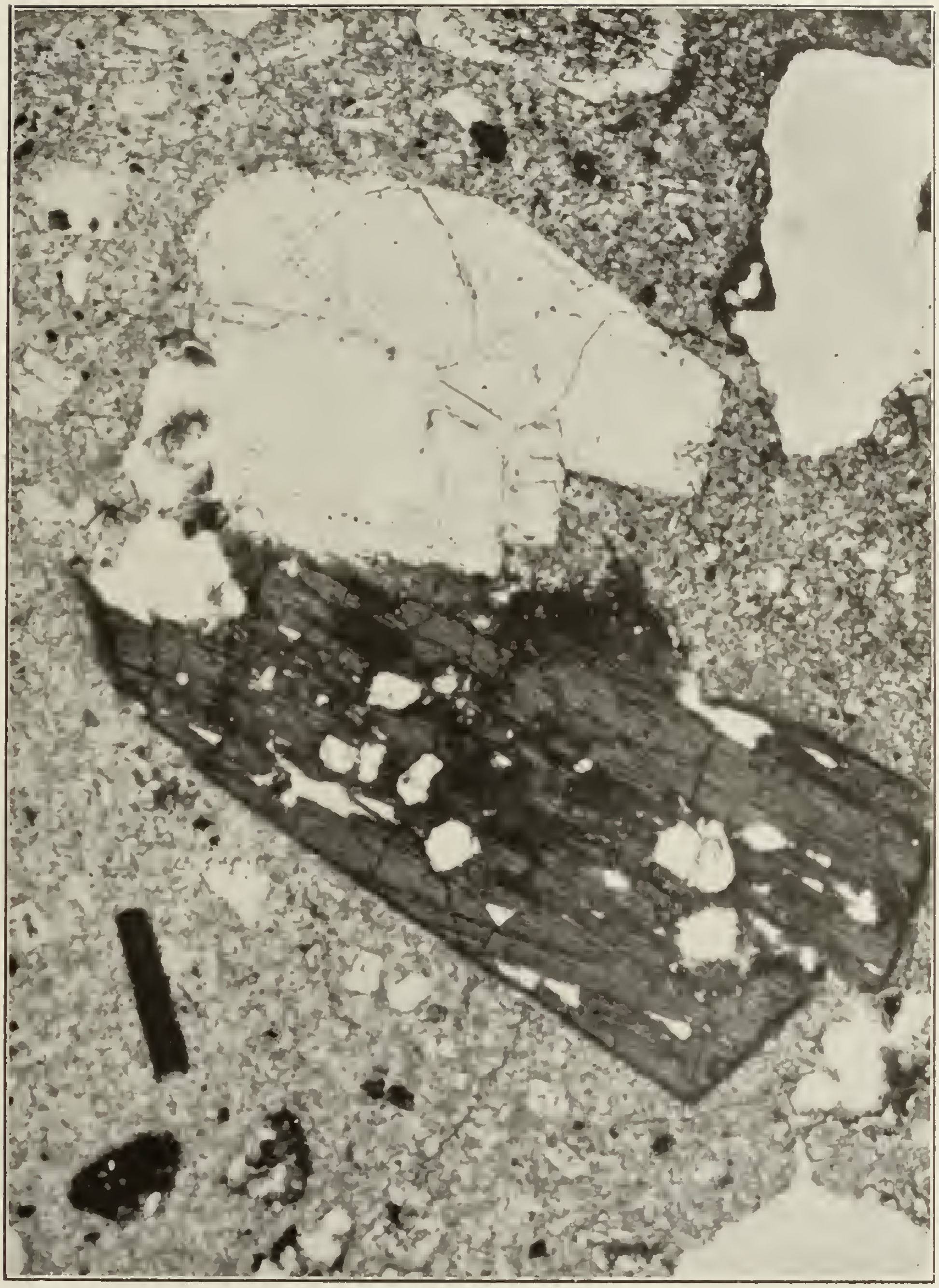
Silica (SiO_2)	60·40
Alumina (Al_2O_3)	17·84
Ferric oxide (Fe_2O_3)	6·40
Manganous oxide (MnO)	0·05
Lime (CaO)	4·30
Magnesia (MgO)	0·13
Potassium-oxide (K_2O)	1·15
Sodium-oxide (Na_2O)	2·46
Titanium-oxide (TiO_2)	0·41
Carbonic anhydride (CO_2)	0·30
Water and organic matter	7·00
Total	100·44

(*b.*) *Pyroxene Andesites.*—The pyroxene andesites are not of very common occurrence among the volcanics of the "Second Period," since augite, while present to a minor extent in almost all the rocks, rarely becomes as abundant as hypersthene.

The general appearance of these rocks and the characters of the groundmass are the same as those of the hypersthene andesites. On the eastern side of the peninsula, pyroxene andesites have been collected from Waihirere Creek and from the coast-line two and a half miles southward, both localities being within the Waikawau – Kennedy's Bay coastal belt. An altered pyroxene andesite from Materangi Hill, Kuaotunu, has been identified by Sollas, and a similar rock from the Otanguru Creek by the writers. Further south occurrences of pyroxene andesites at Wade Creek (Mahakirau Valley), and in the Kaimarama River about a mile from its junction with the Mahakirau, may be mentioned.

* "Rocks of Cape Colville Peninsula," vol. ii, 1906, p. 142.

PLATE XXV.



HORNBLENDE DACITE, TERTIARY VOLCANIC ROCKS OF SECOND PERIOD, SOUTH SIDE OF CABBAGE BAY.

Magnification, 50 diameters. Work of Mr. Alexander McKay, F.G.S.

PLATE XXVI.

Hyalopilitic Hypersthene Andesite, Tertiary Volcanic Rocks of Second Period, North Side of Manaia Harbour.

Magnification, 33 diameters. Work of Mr. Alexander McKay, F.G.S.

In the vicinity of the western coast-line, the only rock determined which should be included under the present heading was a glassy andesite collected from the breccias a short distance to the south of Cabbage Bay.

(*c.*) *Hornblende Andesites.*—Hornblende andesites have a fairly wide range within the areas of the "Second Period" volcanics, both as pyroclastic and massive rocks. The amphibole, however, is a characteristic mineral of many of the intrusions of this period, and, as already stated, it is not possible to discriminate in every case between lava-flows and dykes.

The localities where these rocks have been identified either by Sollas and McKay or by the writers may be submitted.

Hyalopilitic hornblende andesites occur at—

Sugar Loaf Headland (Moehau Survey District): As inclusions of trachytoid appearance in the breccias.

Port Charles – Kennedy's Bay coastal belt: As finely textured basalt-like rocks, or coarsely porphyritic rocks with a dull lithoidal groundmass, in the flows or pyroclastics on the coast-line; as similar rocks in the valley of Pakore Creek, entering Kennedy's Bay on its south side.

Hill between Kikowhakarere Bay and Kapanga Mine (Coromandel): As a grey medium-grained rock with conspicuous feldspar phenocrysts—hypersthene hornblende andesite. The hornblende andesites extend from here southward, forming the coarse breccias of Dacre Hills, and eastward probably to the vicinity of the Blagrove's Freehold Mine.

Micropœcilitic hornblende andesites occur at—

Port Charles – Kennedy's Bay coastal belt: In same localities as does the hyalopilitic type.

Owera Creek (Whangapoua): Near its headwaters, as a dark-coloured rock with small phenocrysts, forming lava-flows.

Kuaotunu – Mercury Bay Road, just beyond Brown's Camp: as a greyish-blue basalt-like rock—hypersthene hornblende andesite.

Waitaia Bay (southern shore-line of Kuaotunu Peninsula): As a coarsely porphyritic rock with groundmass approaching the micro-crystalline structure.

Hooker Creek (Mahakirau): As dark massive rocks, near the contact of the series with the more decomposed volcanics of the "First Period."

Branch Creek (Cabbage Bay): As dark lava-flows in the vicinity of the sandy marls of the Torehine Series: groundmass is obscurely micropœcilitic.

(*d.*) *Dacites.*—Rocks collected from three localities within the areas of the "Second Period" volcanics have been pronounced as dacites by Sollas.

On the eastern side of the subdivision the stratified tuffs from the western spur of Materangi Bluff, and the altered rock from the Murphy's Hill mine-workings (both vein-bearing localities of the Kuaotunu Peninsula), have been designated "hornblende dacites." The other occurrence is on the western side of the subdivision, near the southern shores of Cabbage Bay, where the volcanics are exposed, in the road-cuttings, overlying the old sedimentaries.

(3.) TERTIARY VOLCANIC ROCKS OF THE "THIRD PERIOD."

General Statement.

The volcanic rocks of the "Third Period" (Pliocene ?), in contradistinction to the greater bulk of the older volcanics, are of acidic character. They consist of pyroclastics—pumiceous tuffs, breccias, and fine-grained agglomerates—through which have been extruded flows of spherulitic rhyolite.

These "Third Period" volcanics are confined to the south-eastern portion of the subdivision, where they form the whole area lying to the east of the Whitianga Estuary. This area, differing in geological character from the surrounding country, presents special physiographic features, which have been described in an earlier chapter.

Age.

The age of the "Third Period" volcanics cannot be deduced from any evidence afforded within the area under review. These rhyolites must, however, be considered as overlying uncomformably the andesites of the "Second Period" or Beeson's Island Series, although actual contacts of the rocks have not been observed. The pumiceous agglomerates contain in places small fragments of semi-basic volcanics, such as might have been derived from the Beeson's Island Series; on the other hand, the breccias of the latter series, in the vicinity of Whitianga, have never been found to contain fragments of rhyolitic material.

The relationship of these Hauraki rhyolites to those which cover such a large area in the central part of the North Island has been discussed by the previous investigators, who were familiar with the occurrences in both localities. Park, who considered that the first eruptions of rhyolite in the King-country (central part of North Island) should be referred to the Lower Pliocene period, writes, "The rhyolitic flows of the eastern Hauraki Goldfields are directly connected, and apparently contemporaneous, with those forming the great acidic plateau of the King-country; the author is therefore of opinion that they are of the same age."* McKay, although affirming that this acidic group as developed on the Cape Colville Peninsula must be regarded as belonging to the Pliocene period, remarks, "Having regard to their connection or otherwise with the acidic group of rocks developed in the central region of the North Island around Rotorua and thence extending to Tongariro and Ruapehu, those of the Cape Colville Peninsula cannot be regarded other than as older, and unconformably older, than the pumiceous deposits of the Upper Waitoa Plain, and the extensions of the same rocks to the southward"† (*i.e.*, to the central region of the North Island).

Opinions therefore differ as to correlation of the acidic rocks of the Cape Colville Peninsula with at least certain members of the acidic series of the central portion of the North Island. These rhyolitic rocks of the Coromandel subdivision have, however, by all previous investigators been regarded as Pliocene, and this opinion is shared by the writers of the present bulletin.

Distribution.

The volcanic rocks of the "Third Period" are, as already stated, confined to the south-eastern part of the subdivision. The major area, which covers some twenty-two square miles, is that lying to the eastward of the Whitianga Estuary. To the westward of this physical feature an area of about one square mile, lying to the south of Kaimarama River and including Trigonometrical Station V, consists of these rocks; so also does a very small inlier known as Trelease's Point, lying to the north of the Kaimarama.

Structure, and Conditions of Eruption.

The oldest rocks of this period, which appear in the subdivision, are the pyroclastics. They are disposed, in the main, as horizontal or nearly horizontal beds, but occasionally small patches are inclined at fairly high angles. These pyroclastics pass beneath the low-tide mark, or below the alluvial flats, and nowhere is exposed the basement or older rock upon which they rest. The total thickness of these accumulations is therefore unknown, but the height above sea-level attained by the beds, notwithstanding denudation, still exceeds 500 ft. in places. Jointing is occasionally well marked, and in the case of the harder rocks affords sharply cut cuboidal blocks. Other cliff-faces of pumiceous tuff or fine-grained agglomerate, which are bare and exposed for over 100 ft. in vertical height, exhibit scarcely a single joint, and in such localities it is not uncommon to see a cliff undercut some 20 ft. at its base, without showing the slightest signs of collapse.

There is little evidence bearing on the conditions under which these pumiceous agglomerates were erupted. Small included fragments of semi-basic rocks probably represent the shattering of the older andesitic rocks, through which the rhyolites were extruded. The character of some of the finer-grained

* "Geology and Veins of the Hauraki Goldfields," 1897, p. 40. † C.-9, 1897, p. 68.

tufaceous rocks, and the planes of stratification and current bedding, which are often present, suggest accumulation under subaqueous conditions; so also does a thin band of stratified gravel separating beds of these fragmentals near the north-eastern headland of Whitianga Harbour. Other portions have the appearance of deposition under subaerial conditions.

Extruded through the pyroclastic rocks described, and capping them in many places, are massive rhyolites, generally showing fluxion-banding and spherulitic structure. These rocks, owing partly to their superposition in the series, partly to the greater resistance they offer to weathering agencies, form the higher hills of the dissected plateau-like country extending from the Whitianga Estuary to the eastern coast-line. The massive rhyolites are in places highly silicified, and have associated with them deposits of siliceous sinters, forming mounds and "shoadings" on the crests of some of the hills. These mounds mark the sites of extinct hot silica-bearing springs. In this connection the existing hot springs of Wigmore Creek and Hot Water Beach, which lie within the rhyolitic area, are significant, although the amount of silica contained in these waters is relatively small.

Petrology.

General Statement.—The "Third Period" volcanics, as previously indicated, consist of pumiceous pyroclastic rocks and massive rhyolites.

The pyroclastic rocks, which are all pumiceous, comprise fine-grained sandy tuffs, with minor beds of tufaceous mudstones, fine-grained agglomerates, and fine- and coarse-grained breccias. The massive rocks consist wholly of banded and spherulitic rhyolites. Fragments of black volcanic glass, or obsidian, are in places of fairly common occurrence in the surface débris. This rock was not detected *in situ*, but probably occurs as fragments in certain beds of the pumiceous fragmental rocks.

Pumiceous Tuffs.—The rocks here considered, under the heading of pumiceous tuffs, vary from a white or cream-coloured ashy-looking rock to a drab-coloured rock of rather earthy appearance. The former consists in the main of white fine-grained pumiceous material, with minute dark specks of flow rhyolite and foreign material. It is rather easily pulverised, and affords a soft chalky powder with which is associated a little fine grit. This light-coloured rock is well exhibited in the almost vertical cliffs of Whitianga Rock on the east side of Whitianga Estuary, also in Shakespeare Cliff, and elsewhere. These white walls of rock, with their vertical flutings or corrugations, recall similar features in limestone country, and their remarkable resemblance to cliffs of Oamaru limestone and certain calcareous sandstones in both Islands of New Zealand has been noted by McKay.* The drab-coloured earthy rock is in general similar in mineralogical composition to the white tufaceous rock described, but is of slightly coarser texture, and resembles more a tufaceous sandstone. This rock has its typical development just to the south of "Whitianga Rock," where it occurs in the cliffs bordering the harbour. The rock has a uniform massive appearance, and on the application of an explosive splits readily into large slabs.

A peculiar characteristic of both the white ashy tuff and the drab-coloured earthy tuff is the thin hard siliceous "skin" or segregation which is found to coat their exposed weathered surfaces. This siliceous coating affords an effective barrier to the further progress of weathering action on what is otherwise a soft rock. The slow recession of the cliffs from the shore-line is, therefore, caused rather by undercutting due to marine erosion, and the consequent collapse of the superstructure, than by a general weathering of the cliff-faces.

Pumiceous Agglomerates.—What may be termed a pumiceous fine-grained agglomerate is the most widespread and characteristic of the pyroclastic rocks of this series. The general mass of this rock is white or cream-coloured, and consists of fine-grained pumiceous material interspersed with small subangular and rounded fragments of dark massive rhyolite, and occasionally of semi-basic igneous rocks. These rocks on weathering present similar features to those already described, but the small inclusions of hard massive lavas, as well as of pumice, give rise to rather rough surfaces.

* C.-9, 1897, p. 64.

Under the microscope a section of this rock, collected from a point south of the particular area under review, has been described by Sollas.* The matrix consists of fragments of pumiceous colourless glass and greenish granular material. The included fragments comprise pumice, chiefly of colourless glass; micro-spherulitic rhyolite; fragmentary spherulites; black and colourless glass (the former reddish brown by reflected light); flow rock, composed of ragged feldspar laths and tridymite; magnetite grains, ochreous dust, plagioclase phenocrysts, and broken crystals of hypersthene, hornblende, and augite, &c. Plate XXVII is a fair representation of this rock under magnification of 20 diameters in ordinary light.

This fine-grained agglomerate has considerable development throughout the area lying to the east of Whitianga Harbour, and forms the small inlier, Trelease's Point, on the western side of this arm of the sea.

Pumiceous Breccias.—A rock which may be classed as a pumiceous breccia is composed of yellowish-grey, dark-grey, and white fragments in a faint-pinkish-grey-coloured matrix. The majority of these fragments are about ¼ in., but occasionally exceed 1 in., in largest dimensions, and often show a more or less definite alignment, suggestive of flow structure. Some of this rock shows lenticular flake-like fragments and shreds of dark-brown glassy material. These, as seen in the rock *in situ*, are approximately horizontal, and at times exceed 3 in. in length.

Under the microscope the rock proves to consist mainly of tuff-like fragments of glass, in part of a brownish colour, and somewhat granular (ultra-microscopic), in part colourless and pumiceous with bands and specks of dark dusty material. Scattered throughout this matrix are fragments and fairly complete crystals of plagioclase, showing little lamellar twinning (r.i. above balsam); orthoclase; pieces of finely banded rhyolite; and fragments of the groundmass of flow rocks. Any quartz that may have been present has been torn out of the soft rock in the process of grinding the section.

An alignment of most of the pumiceous fragments and other constituents, as well as the fluxional arrangement of some of the glass, is conspicuous, and gives one the impression that the accumulation of ash prior to final consolidation had been subjected to movement simulating the flow of a lava-stream.

Some of this rock, and particularly that occurring on the outer portion of the eastern headland of Whitianga Harbour, has at least a partial resemblance to the so-called "wilsonite" of Waihi, Waitekauri, and Waikino, in the southern part of the Hauraki Division.† The section made from the Whitianga rock, however, exhibits a much less well-defined flow structure than does the "wilsonite" of the localities cited, and without further investigation the identity of the rocks cannot be claimed.

These types of pumiceous breccia form the greater part of the headland lying to the north of the Ferry Pier, on the east side of Whitianga Harbour, and a somewhat similar rock forms the hills on the west side of the harbour in the vicinity of Trigonometrical Station V. Reference will be made later to the value of this stone for building purposes.

Coarse-grained breccias form only a few beds of inconsiderable thickness within the subdivision. They are occasionally seen in the cliffs of the coast-line, and generally occupy low horizons in these bedded fragmentals. Mineralogically they do not differ from some of the finer-grained pyroclastics already described.

Banded and Spherulitic Rhyolites.—Massive rhyolites, although abundant in the area under description, are all in such an advanced state of surface decomposition that it is difficult to obtain even fairly fresh specimens. The prevailing rock appears to be a pinkish-grey rhyolite consisting almost entirely of spherulites, ranging from ¼ in. in diameter down to microscopic dimensions, with small glistening hexagonal and irregularly shaped flakes of biotite. A few small crystals of quartz and feldspar are also visible. Sections of the rock under the microscope show a mass of closely compressed spherulites of smoky-brown colour, which only feebly transmit light between crossed nicols. Plates of deep-brown strongly pleochroic biotite, grains and small crystals of quartz, plagioclase, and orthoclase, are interspersed throughout the spherulitic mass.

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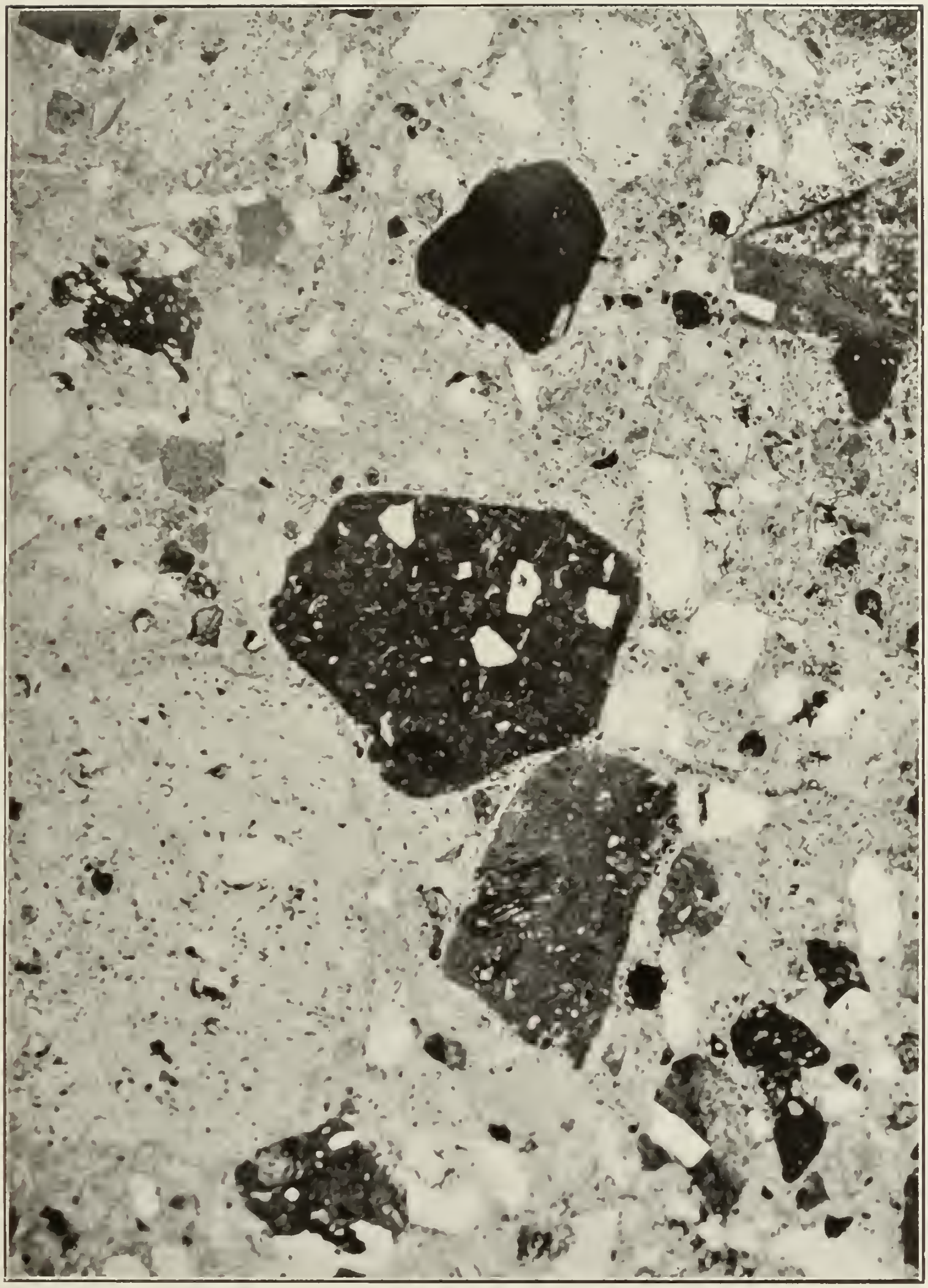
* "Rocks of Cape Colville Peninsula," vol. i, 1905, p. 220. † *Loc. cit.*, vol. i, 1905, pp. 123, 124.

PLATE XXVII.



Pumiceous Fine-grained Agglomerate, Tertiary Volcanic Rocks of Third Period, as at Whitianga.

Magnification, 20 diameters. Work of Mr. Alexander McKay, F.G.S.

An analysis of this rhyolite resulted as follows :—

Silica (SiO_2)	72·40
Alumina (Al_2O_3)	14·09
Ferric oxide (Fe_2O_3)	0·48
Ferrous oxide (FeO)	2·52
Manganous oxide (MnO)	0·42
Lime (CaO)	1·15
Magnesia (MgO)	0·20
Potassium-oxide (K_2O)	4·09
Sodium-oxide (Na_2O)	2·97
Titanium-oxide (TiO_2)	0·15
Carbonic anhydride (CO_2)	0·82
Water and organic matter	0·86
Total	100·15

The banded rhyolites show a similar mineralogical composition to those just described, but the spherulites attain much greater dimensions, sometimes exceeding 1 in. in diameter. Bands in which the larger spherulites, or more frequently the spherical cavities formed by the decomposition of the spherulites, predominate, are found alternating with bands showing a finely laminated structure, the laminæ being evidently coincident with the fluxion planes. These banded and spherulitic rhyolites form most of the higher hills in the central portion of the area between Whitianga Harbour and the eastern coast-line, and the whole of the hilly country between Wigmore Creek and Hot Water Beach.

The fragments of black volcanic glass, to which reference has been made, contain a few small white spherulites, and often show lamination due to flow. This rock has been described by Park and Rutley, who say, "Under the microscope, between crossed nicols, it appears to be completely isotropic with the exception of one or two brown spherulites." A small crystal of plagioclase, containing a prism or two of apatite, is enclosed in one of these spherulites; epidote is another mineral which has been detected as minute crystals. "In ordinary transmitted light the section is seen to contain numerous trichites and longulites, the latter especially as a rule forming narrow bands in the direction of flow. A few globulites are also present."*

(4.) INTRUSIVE ROCKS OF VARIOUS PERIODS.

General Statement.

Intrusive igneous rocks, representing apparently a considerable range in time, are largely developed within the Coromandel subdivision. They are found associated with each of the series of sedimentary rocks already described, and with the Tertiary effusive rocks of the "First" and the "Second Period," which overlie these sedimentaries.

Considered from the chemical point of view, these intrusives fall into two classes—(*a*) the semi-basic and (*b*) the acidic. The former class is represented by diorites, porphyrites, dacites, and andesites, occurring in considerable abundance, while the latter is represented only by rhyolites existing in two separate localities.

(*a*.) The Semi-basic Intrusives.

General Distribution.

The great abundance of semi-basic dykes and sills associated with the rocks of the Tokatea Hill Series is characteristic of all areas in which these old stratified rocks are developed. The small inlier of this series in Whaiwango (Big Paul's) Creek the major belt extending from north of Tokatea Hill to

* Q.J.G.S., 1899, vol. lv, p. 453.

the Tiki Creek, and the area within the Manaia Valley are marked by an abundance of intrusives, particularly hornblende porphyrites.

The strata of the Moehau Series, more or less throughout their whole extent, but more particularly in certain localities, are intruded by semi-basic dykes and sills. The locality especially characterized by these irruptives is that of the western flanks of Moehau Range, where a considerable area consists entirely of diorites, porphyrites, dacites, and andesites presenting considerable petrographical variety. The relative paucity of intrusives associated with the comparatively extensive belts of the Manaia Hill Series on both sides of the main divide is rather pronounced.

The igneous rocks intruding the Manaia Hill Series, moreover, exhibit a nearer approach to the andesitic facies than do the greater number of those associated with the older groups of sedimentaries *

Definitely ascertained dykes are not numerous in association with the volcanics of the "First Period." Mining operations have, however, revealed the existence of intrusives in certain localities where no signs of such are recognisable at the surface. The close similarity of the weathered products of both the effusive and the dyke rocks, together with the heavy overmantle of débris which almost everywhere covers the country, sufficiently accounts for the fewness of the intrusives detected in these andesitic areas. By far the most conspicuous dyke intersecting these volcanics is that forming Castle Rock, Motutere, &c., on the crest of the main divide. This rock is a hornblende hypersthene dacite.

Intrusives intersecting the volcanics of the "Second Period" are by no means uncommon, but, being generally andesitic, are often not to be distinguished with certainty from the lava-flows. The ascertained dykes in these rocks are mostly exhibited in the steep cliffs and marine shelves of the coast-line; elsewhere there obtain conditions somewhat similar to those noticed in connection with the older volcanics, and render the detection of dyke rocks difficult.

Age.

As demonstrated in previous sections of this chapter, a Tertiary age can with certainty be assigned to the great pile of effusive rocks which have been extruded through, and rest upon, the basement sedimentaries of the area under review. Certain outliers of andesitic lavas and breccias, particularly the one found near the very crest of Te Moehau Mountain, further suggest that the Tertiary effusives formerly covered a very much greater area of the sedimentary rocks than they do at present. A large number of dykes and sills are now exposed on the denuded and worn-down surface of the basement folded complex, more especially in that part of it consisting of the Tokatea Hill Series and the Moehau Series. It is reasonable to infer that some of these irruptives are the hypabyssal analogues of the Tertiary effusive rocks, which formerly existed in these particular localities. Others, again, are probably coeval in age with the dykes which are found intruding, in other localities, these "First" and "Second Period" effusives.

While many of the dykes and sills associated with the Tokatea Hill and Moehau rocks are doubtless of Tertiary age, there is sufficient evidence to conclude that some are of considerably greater antiquity. The facts upon which this conclusion is based may be briefly narrated: (*a.*) The Jurassic rocks (Manaia Hill Series) contain remarkably few intrusives, even where these strata lie immediately adjacent to the areas of the Tokatea Hill Series (Pre-Jurassic), crowded with dykes and sills. (Compare conditions in Matawai and Tiki Creeks, page 41.) (*b.*) The fine grained Jurassic conglomerates contain bands or pebble-beds, in which occur well-rounded boulders of igneous rocks, ranging up to 2 in. in diameter. These boulders show a strong lithological resemblance to the dyke rocks intruding the Pre-Jurassic sediments (Tokatea Hill and Moehau Series), and were probably derived from these or other intrusives coeval in age with them. This seems the only possible explanation which will account for these fairly large, and therefore locally derived, boulders. (*c.*) The occurrence of holocrystalline rocks, as intrusives in the Moehau Series, is significant. These holocrystalline rocks, which occur on the western slopes of Moehau Range and extend to its actual crest, may reasonably be considered to have consolidated

* Though, according to many petrologists, it is desirable to employ separate names for dykes and other intrusive rocks, the writers found that many occurrences of the rocks in the Coromandel subdivision coming under the heading of intrusives showed no distinctive points of difference from ordinary volcanic rocks, and therefore they considered it inadvisable to make use of names which would imply different characters. On the other hand, certain intrusives presented all the characteristics of diorite, and that name has therefore been retained for such rocks.

at some considerable depth. Since a small outlier of effusive andesites, as already mentioned, is still preserved near the summit of Te Moehau Mountain, no very great thickness of sedimentary rock can have been removed by denudation since early Tertiary times. The diorite was therefore probably intruded into the sedimentaries, and subsequently exposed or partly exposed by denudation, prior to the manifestations of Tertiary vulcanism. That the diorite is of greater age than at least some of the andesites is proved by an occurrence in Sorry Mary Creek. The light-grey diorite, exposed in this creek-bed at about 25 chains from the mouth, is intersected by a small dyke of dark pyroxene andesite, the two rocks presenting a rather marked contrast in the relative states of their preservation. No diorites or diorite porphyrites have been detected intruding the Jurassic strata (Manaia Hill Series). Andesite and to a lesser extent porphyrite, the latter rock ge erally showing an approach to the andesitic facies, constitute the comparatively few dykes that do occur in these beds.

It would appear from the above considerations that the rocks of the Tokatea Hill and Moehau Series were intruded by semi-basic igneous rocks prior to the deposition of the Manaia Hill Series. Contemporaneous with the extrusion of the Tertiary volcanics, these old sedimentaries, and with them the younger Manaia Hill Series, were again intruded by igneous rocks.

On account of the general similarity in chemical composition of the older and younger intrusives, it is impossible to separate them, but, as already suggested, some of the more crystalline of these irruptives are probably referable to a Pre-Jurassic age, while most of the less crystalline are Tertiary. The area affords no evidence by means of which the age of the Pre-Jurassic intrusives may be fixed more definitely.

The actual period of intrusion of the various semi-basic dykes that have been recognised in association with the Tertiary effusive rocks is a matter of lesser interest, and, while necessarily younger than the actual volcanic accumulations in which they occur, there are few criteria by which their age can be more closely determined. It would appear that the latter part of the "Second Period" (Miocene ?) was especially characterized by the intrusion of dyke rocks into the consolidated or partially consolidated volcanic accumulations. The greater alteration, however, of the earlier intrusives in the volcanics, and the consequent failure to recognise many of them, must, in this connection, not be overlooked. Some of the previous investigators in this district have ascribed a Miocene age to the great Castle Rock dyke which intersects the volcanics of the "First Period," but, while this may be correct, it cannot be affirmed with any degree of certainty.

Petrology.

The semi-basic intrusives consist of quartz-biotite diorite, quartz diorite, diorite porphyrite, hornblende porphyrite, pyroxene porphyrite, dacites, and hornblende-, hypersthene-, and pyroxene-andesites. Many of the dyke rocks are so much altered that they do not admit of definite classification, and can only be described as altered porphyrites, altered andesites, &c., but these are doubtless referable to one or other of the above types.

Quartz-biotite Diorite.—The quartz-biotite diorite is of both economic importance and petrographical interest. It is a grey-coloured granite-like rock, showing megascopically white feldspar, greenish-black biotite, and other ferro-magnesian minerals of medium grain. A little pyrite is sparsely distributed throughout some specimens. Under the microscope* the rock is observed to be holocrystalline, with the hypidiomorphic granular structure. The feldspars are dispersed as numerous opposed crystals, the interstices between the crystals being filled with quartz. Zonal structure and twinning on the albite, pericline, and Carlsbad plans are all observable. Minute crystals of augite and hypersthene occur as inclusions in the feldspar. Separated by specific gravity the principal feldspar is found to be andesine (s.g. 2·675), but some labradorite (s.g. 2·74) is present, and a little orthoclase (s.g. 2·547). Quartz is interstitial or occurs as large grains containing irregular liquid-cavities with bubbles, also belonite-like crystallites. Biotite forms fairly large corroded crystals with apatite inclusions, and acquires a greenish colour on weathering. In association with the biotite is hornblende as greenish corroded crystals, often showing twinning. Magnetite, ilmenite, and sphene constitute the minor

* Microscopic details which follow are those given in "Rocks of Cape Colville Peninsula," vol. i, 1905, p. 254.

accessories. The minerals of the rock were separated and quantitatively estimated (by Sollas), with the following result :—

	Per Cent.
" Orthoclase	3·8
Andesine (formula Al_2An_1)	51·6
Biotite	21·1
Hornblende	4·8
Quartz (including feldspar of sp. gr. 2·65)	17·0
Magnetite	1·1
Zircons, &c.	0·6
	100·0 "

A specimen of this diorite collected by the writers was submitted to chemical analysis, the result being as under :—

Silica (SiO_2)	57·32
Alumina (Al_2O_3)	17·69
Ferric oxide (Fe_2O_3)	2·24
Ferrous oxide (FeO)	5·62
Manganous oxide (MnO)	0·21
Lime (CaO)	6·50
Magnesia (MgO)	3·66
Potassium-oxide (K_2O)	1·25
Sodium-oxide (Na_2O)	4·04
Titanium-oxide (TiO_2)	0.85
Carbonic anhydride (CO_2)	0·67
Water and organic matter	0·13
	100·18

The percentage of silica (57·32) is rather low for a rock of the quartz diorite class, and the chemical analysis agrees more closely with those of normal diorites. The rock has considerable development on the western slopes of Moehau Range, particularly in the spur which terminates at the sea-border some 60 chains north of Darkie Creek.

The suitability of this rock as a building-stone is discussed in another section of this chapter (see page 96).

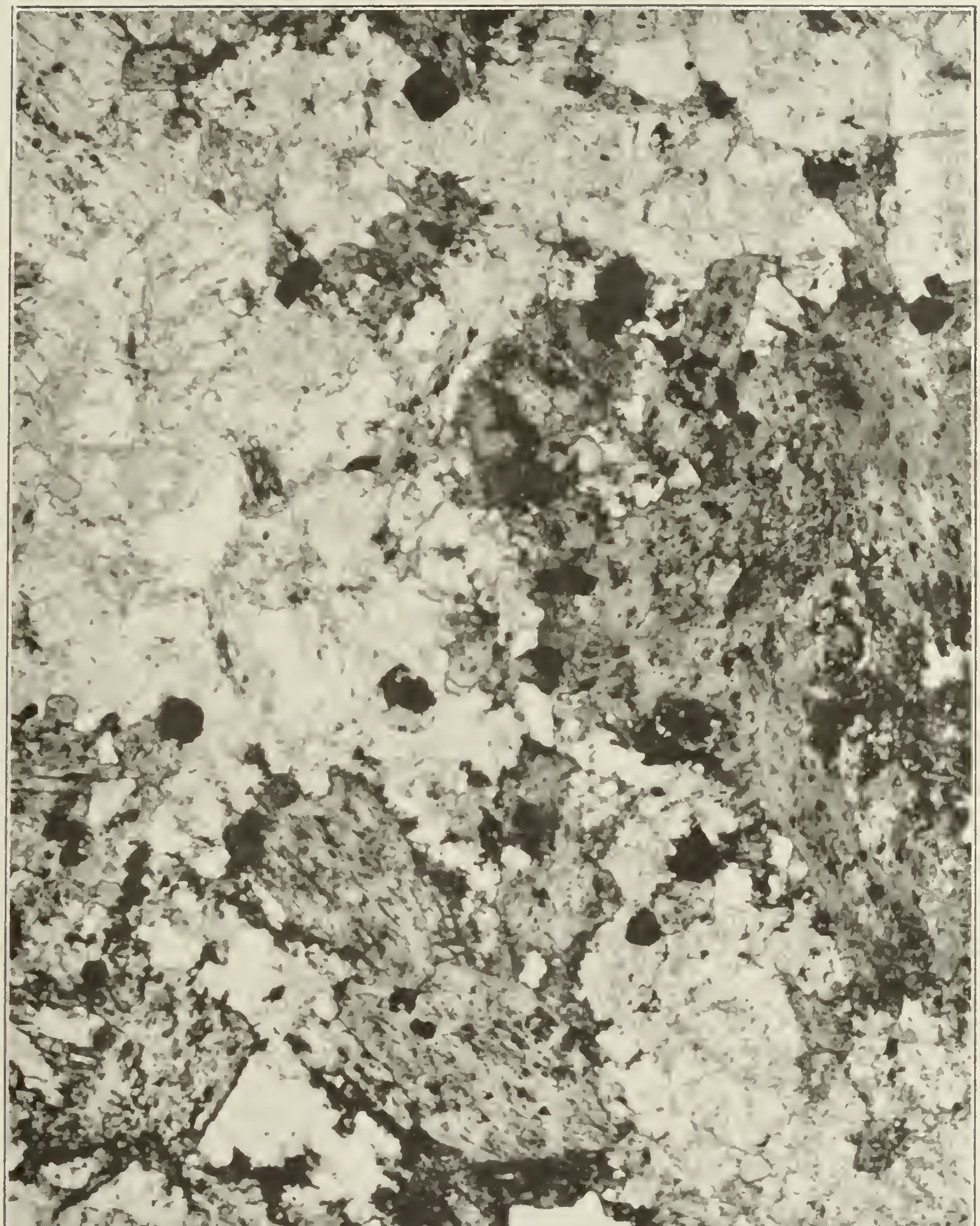
Quartz Diorite.—The quartz diorite is somewhat similar in megascopic appearance to the type just described. Under the microscope this holocrystalline rock consists of plagioclase (extinction angles up to 30°), greenish hornblende partly derived from pyroxene (uralite), and interstitial quartz showing micrographic intergrowths. Biotite is absent. The minor accessories are ilmenite and apatite.

This quartz diorite has considerable development in Ohinewai and Darkie Creeks, on the western flanks of Moehau Range. It is often considerably altered and pyritised, and neither the extent of the intrusions, nor their relationship to the other types of the igneous rocks existent in the vicinity, is apparent.

Diorite Porphyrite.—Intrusive rocks exhibiting phases of gradation between the diorites just described and the porphyrites to be next considered, are not uncommon. A type which may be designated a quartz-biotite-diorite-porphyrite occurs near the head of Ohinewai Creek and also near the coast-line between this creek and the Ongahi Creek. Rocks designated by Sollas "quartz-biotite-diorite-porphyrite" and "quartz - augite diorite porphyrite" were collected by McKay from the boulder banks of the coast-line near the mouth of Waiaro Creek, and evidently have been derived from the western spurs of Te Moehau.

Hornblende Porphyrites.—Under the heading of hornblende porphyrites, has been grouped a widespread series of dyke rocks, in which hornblende is, or has been, the dominant ferro-magnesian mineral. They may be regarded as standing between the diorites on the one hand and the dacites

PLATE XXVIII.



Quartz Diorite, Dyke Rock, Western Slope Te Moehau Mountain.

Magnification, 50 diameters. Work of Mr. Alexander McKay, F.G.S.

and andesites on the other. These rocks, which vary from light grey to dark grey in colour, have the porphyritic structure characteristic of this particular class. The matrix in which the phenocrysts are set varies from micropœcilitic to almost granitic, and is sometimes abundant, or again constitutes a relatively small proportion of the rock.

The plagioclases, which show the usual zonal structure, twinning lamellæ, and inclusions, vary in the main from andesine to acid labradorite. The pleochroic hornblende of yellowish to greenish colour with resorption borders, usually shows considerable alteration, as in the effusive andesites. Augite and hypersthene are occasionally present as subsidiary constituents. Quartz, to a lesser or greater extent, occurs in all these porphyrites, either interstitial or as small medium-sized grains with various inclusions. The minor accessories are magnetite, ilmenite, apatite, and zircons. The alteration-products of these primary mineral constituents do not differ materially from those occurring in the effusive rocks. Having regard to the quartz-content of these rocks, Professor Sollas has termed many of them "hornblende dacite porphyrites." While, however, some of these porphyrites have their less crystalline analogues in the dacites, others may reasonably be supposed to represent the hypabyssal equivalents of the more predominant effusive rocks—namely, andesites—so that the more general term "hornblende porphyrite" has been preferred in this bulletin.

Hornblende porphyrites or altered porphyrites, in which hornblende was probably the dominant ferro-magnesian constituent, have been identified as occurring at the following localities :—

(*a.*) As dykes or sills in the Tokatea Hill Series :—

Whaiwango (Big Paul's) Creek : Dykes appear in both branches, close to the main junction.

Harataunga Stream, in the branch following closely the Tokatea - Kennedy's Bay Road : Dyke occurs at first waterfall seen on descending this road from the Tokatea Saddle.

Tokatea Hill, in No. 7 level of the Royal Oak (Tokatea) Mine : Dyke occurs at 1,600 ft. from the mouth of level.

Petote Creek : Dykes considerably altered are exposed in the creek-bed at various intervals.

Tiki Creek, and its tributary the Pukewhau : Dykes occur at frequent intervals ; some may correspond with those exposed in Petote Creek.

Matawai Creek : Dykes occur in bed of main right-hand branch, within half a mile of Opitonui Saddle.

Manaia River : Numerous dykes, sills, and plugs are conspicuous in both main branches ; many of the rocks, however, are considerably altered.

(*b.*) As dykes or sills in the Moehau Series :—

Coast-line 10 chains north of the mouth of Fantail Creek (Moehau Survey District).

Moehau Mountain, on the actual summit, and extending for some 30 chains to the north-west.

Sorry Mary Creek, 20 chains from the coast-line (altered rock).

Hope Creek : Main exposure, 20 chains wide, about half a mile from coast-line, smaller exposures higher up the creek.

(*c.*) As dykes or sills in the Manaia Hill Series :—

Whareroa Creek (Kennedy's Bay) : Intrusives, considerably altered, occurring just below the first main junction above the Huakitoetoe junction.

(*d.*) As dykes intersecting the volcanics of the "First Period" :—

Golden Pah Mine (Coromandel) : Forming a hard bar in workings, and probably extending into the Union Beach section of the Hauraki Mine.

Maiden Mine (Opitonui) : A rock collected by McKay from tip-head ; probably forms a dyke in the mine-workings.*

(*e.*) As dykes intersecting the volcanics of the "Second Period" :—

Otanguru Creek, in left-branch about 16 chains above the main junction.

Howell Creek (Mahakirau), near head.

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* "Rocks of Cape Colville Peninsula," vol. i, 1905, p. 206.

Pyroxene Porphyrite.—The pyroxene porphyrites, which are of comparatively rare occurrence, are closely related to the hornblende porphyrites, the pyroxenes, which are frequent accessory minerals in the latter type, having in this case become the dominant coloured elements. A specimen of a pyroxene porphyrite from the western coast-line in Moehau Survey District shows a few ragged plates of deeply pleochroic biotite. A somewhat similar rock constitutes the dyke in the Manaia Hill Series at the junction of the Taurarahi Creek with the Manaia.

Rocks in which pyroxene was originally the dominant ferro-magnesian constituent are the comparatively rare uralite porphyrites. These generally contain fairly large grains of quartz. Uralite porphyrite has been identified by Sollas as forming a dyke in the main branch of Tiki Creek, and another in Cadman Creek.

The Dacites.—The dacites occurring as intrusives usually vary in colour from light grey to dark grey or almost black, and show small phenocrysts of feldspar and ferro-magnesian minerals. Under the microscope they are seen to differ little from the effusive dacites, excepting in the nearer approach to the crystalline structure in the groundmass. In the great majority of the dacites hornblende is the dominant ferro-magnesian mineral. The quartz occurs either in the matrix, as irregularly shaped grains sometimes attaining a size comparable with that of the phenocrysts, or less frequently as fairly large corroded grains. Most of the rocks show considerable alteration, pyrite in some being fairly abundant.

Rocks determined as dacites have been collected from the following localities :—

As intrusives in the Tokatea Hill Series :—

Cadman Creek, not far above the junction with the Petote Creek : Altered dacite (Sollas).

Tiki Creek, from right or main branch : Hornblende dacite (Sollas).

Pukewhau Creek (branch of Tiki) : Several intrusions of altered dacite.

As intrusives in the Moehau Series :—

Western coast-line (Moehau Survey District), 15 chains north of Fantail Creek : Altered hornblende dacite.

Fantail Creek (Moehau), about one mile from mouth : Hornblende dacite (m.).

Western coast-line (Moehau Survey District), 17 chains north of Waiaro Creek : Hornblende dacite (m.).

Boulders from shore-line near mouth of Waiaro Creek (collected by McKay), probably derived from western flanks of Moehau : Hornblende dacite (Sollas) ; microgranitic dacite (Sollas).

As a dyke in volcanic rocks of the " First Period " :—

Castle Rock (Motutere), the most conspicuous dyke in the subdivision : A hypersthene hornblende dacite.

The Andesites.—Intrusive andesites are found associated with the Tokatea Hill, Moehau, Manaia Hill, and Torehine Series of stratified rocks, and also with the " First " and " Second Period " volcanics. These andesites show the same assemblage of constituent minerals as do those occurring as effusives. The micropœcilitic matrix is the most common type, but the hyalopilitic is also represented. The following occurrences may be noted :—

(*a.*) As intrusives in the Tokatea Hill Series :—

Altered andesites occur in the headwaters of the Waverley Creek (a tributary of the Harataunga), in Maddern and Tiki Creeks, and elsewhere.

(*b.*) As intrusives in the Moehau Series :—

They are of fairly common occurrence throughout the whole extent of the Colville and Moehau Survey Districts as dykes and sills. Hornblende-, pyroxene-, and hypersthene-andesites have all been recognised.

A dyke of pyroxene andesite in Sorry Mary Creek, about 25 chains from the coast-line, should be specially mentioned as intersecting the altered dioritic intrusive rock of this locality.

(*c.*) As intrusives in the Manaia Hill Series :—

Western coast-line (Harataunga Survey District), south of the mouth of Tawhetarangi Creek : Hypersthene hornblende andesite (h.) (Sollas).

Waiau River, about a mile and a half above junction of Matawai : A hornblende pyroxene andesite (h).

(*d.*) As intrusives in the Torehine Series :—

Omoho Creek, dyke 2 ft. to 3 ft. wide intersecting both Moehau and Torehine Series : An altered hypersthene andesite, containing a little hornblende.

(*e.*) As intrusives in the volcanics of the " First Period " :—

Omoho Creek, in gorge below the first exposure of the Torehine Series : Hornblende andesite (m.), cutting rhyolitic tuffs. The same dyke appears again in a small left-hand branch entering the main creek at the lower part of the gorge, and is still in association with the acidic effusives.

Wairakau Creek (Harataunga), at the junction of the main headwater branches : Altered pyroxene andesite is intrusive in the effusive andesites.

Maitaiterangi Creek (Harataunga) : Several intrusions of altered hypersthene(?) andesite occur in the headwater branches.

Kopurukaitai Creek (Harataunga), in main creek about 30 chains above junction of Four-in-Hand Creek : A belt of hypersthene hornblende andesite is apparently intrusive.

Trig. Hill (Coromandel), in the shaft of the Kathleen Crown Mine, south-west of Trigonometrical Station E : A dark felsitic-looking rock, much fresher than those of the immediate vicinity, was encountered. Sollas, who has pronounced it hornblende andesite containing quartz in the groundmass, remarks, " The matrix is not pilotaxitic, but a minutely crystalline admixture." * This rock, which is probably a dyke in the effusive volcanics, gave on analysis the following result :—

Silica (SiO_2)	57·32
Alumina (Al_2O_3)	16·56
Ferric oxide (Fe_2O_3)	9·28
Manganous oxide (MnO)	0·25
Lime (CaO)	6·05
Magnesia (MgO)	0·12
Potash (K_2O)	1·52
Soda (Na_2O)	2·38
Titanic oxide (TiO_2)	0·48
Sulphuric anhydride (SO_3)	Nil
Carbonic anhydride (CO_2)	3·20
Water and organic matter	2·50
	99·66

(*f.*) As intrusives in the volcanics of the " Second Period."

These, as already remarked, are numerous, but are with difficulty distinguished from the lava-streams. When their intrusive character is most apparent their positions have been indicated on the maps. These intrusives differ little in lithological character from the effusive rocks already described. Two closely associated and conspicuous ribs of rock on the southern shore of Kikowhakarere Bay (Coromandel) are worthy of notice owing to their proximity to the principal mining-area of the subdivision. The lighter-coloured porphyritic rock has been pronounced an altered hornblende dacite,† the quartz being confined to the minutely crystalline groundmass. The petrographical description of this rock, and of the one occurring in the Kathleen Crown Mine compares very closely, and the intrusives are probably identical.

* Sollas and McKay : " Rocks of Cape Colville Peninsula," vol. i, 1905, p. 140. † *Loc. cit.*, vol. i, p. 144, No. 2868.

The other dyke rock, which is a compact basalt-like rock* glistening with feldspar, has been designated a hornblende enstatite(?) andesite (m.).

(b.) Acidic Intrusives.

General Statement.

The acidic intrusives have, in comparison with those of semi-basic character, an inconsiderable development within the area of this subdivision. They consist of dykes of rhyolite, which are probably referable to a Tertiary age.

Distribution and Structure.

Only two rhyolite dykes have been definitely ascertained as existing in this area—namely, one on the eastern slopes of Tokatea Hill, within the Harataunga watershed, the other within a head-water valley of the Umangawha.

The former dyke constitutes the conspicuous ridge of white rock that extends nearly due north from a point within 4 chains of the Plutus Road to the second waterfall of the creek rising in Tokatea Saddle. The Tokatea – Kennedy's Bay Road, which passes close to this waterfall, has been cut through the dyke. The further extension of the intrusive northward from this point is not apparent, but it may be expected to occur in the vicinity of the Royal Oak battery. This dyke, which ranges from 3 to 4 chains in width, intersects the stratified rocks of the Tokatea Hill Series, and apparently dips at high angles to the westward. The rhyolite, as exposed on the steep face of the south side of the creek at the waterfall, exhibits columnar structure, but at a higher elevation on the sharp ridge extending southward it shows flow structure on a large scale, thus simulating a lava-stream. In certain localities this white rock presents an earthy chalk-like appearance.

The rhyolitic intrusive in the Umangawha Valley occurs in the main headwater branch of the stream, at a point about 90 chains in a straight line from the junction of Branch Creek. The exposure, which is a small one, was located on the right-hand side of the creek, and the intrusive appears to be associated with the altered acidic tuffs overlying at this point the old sedimentary rocks (Moehau Series). It is more than probable that in the rough bush country of the Umangawha Valley, other rhyolitic dykes exist in association with the belt of acidic effusive rocks already described.

Age.

The age of these rhyolitic dykes may be based on the assumptions that the occurrence in the Umangawha is irruptive into the acidic effusives of early Tertiary age, and that this dyke and that at Tokatea can be correlated on their similar lithological characteristics. Since rhyolitic intrusions have never been found associated with the andesitic rocks of the " First " or " Second Periods," the irruption of these dykes apparently followed close upon the extrusion of the rhyolites, constituting the earliest(?) of the " First Period " volcanics.

Petrology.

The intrusive rhyolite from Tokatea is a white or greyish-white rock, strewn with quartz grains or showing numerous small cavities from which small grains or bipyramids of quartz, cubes of pyrite, and other minerals have disappeared. Under the microscope† the groundmass of this rock consists of a mosaic of interlocking quartz grains, dusty with sericite, and opaque white granules. In this ground-mass grains of quartz, some rounded, others bipyramidal, are scattered like phenocrysts, and contain liquid and vapour cavities. Aggregates of muscovite with rectilinear boundaries are clearly pseudo-morphs after some other mineral, and the outlines in some cases suggest a feldspar.

The Umangawha rock is megascopically identical with that just described, except that it contains small isolated plates of deep-brown biotite, which mineral is gradually being replaced by quartz. The rock is therefore somewhat less altered than that at Tokatea, which lies within a well-known vein-bearing area.

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* "Rocks of Cape Colville Peninsula," vol. i, p. 146, No. 2869.

† *Loc. cit.*, vol. i, p. 180, No. 69/3208.

(5.) SUCCESSION OF LAVAS.

The chemical analyses of the various igneous rocks have, for purposes of comparison, been brought together in the following tabulation :—

	First Period.					Second Period.		Third Period.	Intrusive.	
	1.	2.	3.	4.	5.*	6.	7.	8.	9.	10.
Silica (SiO_2)	69·30	57·25	55·58	53·28	48·90	57·68	60·40	72·40	57·32	57·32
Alumina (Al_2O_3)	13·92	16·39	17·27	17·54	17·67	18·84	17·84	14·09	17·69	16·56
Ferric oxide (Fe_2O_3) ..	0·48	0·40	1·12	1·20	1·20	4·96	6·40	0·48	2·24	9·28
Ferrous oxide (FeO) ..	2·81	7·35	7·41	7·92	7·06	1·44	..	2·52	5·62	..
Manganous oxide (MnO) ..	0·42	0·36	0·40	0·78	0·19	0·21	0·05	0·42	0·21	0·25
Lime (CaO)	2·17	4·50	7·30	7·70	11·00	6·05	4·30	1·15	6·50	6·05
Magnesia (MgO)	0·25	3·55	4·85	5·26	3·91	4·00	0·13	0·20	3·66	0·12
Potassium-oxide (K_2O) ..	3·79	1·97	0·46	0·26	0·34	2·15	1·15	4·09	1·25	1·52
Sodium-oxide (Na_2O) ..	1·44	2·37	1·50	2·01	1·89	2·16	2·46	2·97	4·04	2·38
Titanium-oxide (TiO_2) ..	0·18	0·92	0·67	0·61	0·98	0·82	0·41	0·15	0·85	0·48
Carbonic anhydride (CO_2) ..	2·56	1·38	1·45	1·24	4·87	0·75	0·30	0·82	0·67	3·20
Water and organic matter ..	2·40	3·25	2·05	2·08	2·28	0·90	7·00	0·86	0·13	2·50
	99·72	99·69	100·06	99·88	100·29	99·96	100·44	100·15	100·18	99·66

* The greater alteration of this rock, as shown by the percentage of lime and carbonic anhydride contained therein, partly accounts for its low percentage of silica.

1. Rhyolite tuff, from Omoho Creek. (Page 64.)
2. Hornblende andesite, from Waikoromiko Creek. (Page 73.)
3. Hypersthene andesite, from Four-in-Hand Mine. (Page 70.)
4. Augite andesite, from Maiden Mine. (Page 71.)
5. Andesite, showing free quartz—dacitic(?)—from Whangarahi Creek. (Page 74.)
6. Hypersthene andesite, from Beeson's Island. (Page 82.)
7. Andesite(?), from Long Bay. (Page 82.)
8. Spherulitic rhyolite, from Purangi. (Page 87.)
9. Quartz-biotite diorite, from Moehau. (Page 90.)
10. Hornblende andesite with free quartz (probably "Second Period" rock), from Trig. Hill (Coromandel). (Page 93.)

It seems probable that the whole of the Tertiary igneous rocks have been derived by a process of differentiation from a common magma.

It is difficult to account for the existence of the rhyolite (1). This rock, which was the first or one of the first extruded in Tertiary times, appears in only one locality, and covers a relatively small area. Its extrusion was immediately succeeded by eruptions of andesitic rocks, which continued intermittently to the close of the "Second Period."

Certain considerations favour the "assimilation theory" as accounting for this apparently minor and isolated extrusion of rhyolite. It seems reasonable to suppose that, if an andesitic magma, in "stoping" its way up to the surface, encountered in a certain locality a considerable stratum of rhyolite, its first extrusion would afford a lava at least moderately acid, and therefore such as the rock under consideration. Immediately to the south of the rhyolitic extrusion under discussion older rhyolites do occur as heavy interstratified bands in the Tokatea Hill Series, and such may reasonably be supposed to underlie the strata of the Moehau Series upon which the Tertiary rhyolite (1) rests. It is also significant in this connection that the principal rhyolite dyke (Tertiary ?—see page 94) exposed in the basement sedimentaries is associated with the old interbedded rhyolites of this same locality.

Apart from the rhyolite discussed, the Tertiary lavas of the subdivision present on the whole a gradually increasing acidity :—

"First Period," andesites, 48·90 to 57·25 per cent. of silica (SiO_2) ; or, excluding No. 5, 53·28 to 57·25 per cent. of silica (SiO_2).

"Second Period," andesites, 57·68 to 60·40 per cent. of silica (SiO_2).

"Third Period," rhyolites, 72·40 per cent. of silica (SiO_2).

These silica percentages are, however, subject to the alterations which the rocks have undergone.

In the typical Beeson's Island andesite ("Second Period") the percentages of potash and soda are almost equal, and the rock appears to occupy an intermediate position between the "First Period" andesites, in which soda is in excess, and the "Third Period" rhyolites, in which potash is in excess.

As regards the intrusive rocks, the andesite (10) probably belongs to the "Second Period" of vulcanism, and agrees fairly closely with the effusives.

The quartz diorite (9) (see page 88) may be of Pre-Jurassic age, but has apparently been derived from a magma differing little in chemical composition from that which supplied the Tertiary andesites.

(6.) IGNEOUS ROCKS AS BUILDING-STONES.

The semi-basic igneous rocks of the area under review afford few stones suitable for building purposes. The great majority of the rocks possess a texture and appearance, as well as a lack of rift, which renders them altogether unsuitable for architectural work. In addition to these inherent disadvantages, very many of the rocks show considerable alteration due to hydrothermal action. This alteration results in very great diminution in the general strength and durability of the rocks, and thus renders them useless even for the roughest constructional purposes.

Diorite.—The rock of greatest commercial value yet located in the area is the quartz-biotite diorite, occurring on the western slopes of Moehau Range. This is a greyish granite-like rock showing white feldspar, greenish-black biotite, and other ferro-magnesian minerals of even grain. Both the mineralogical and chemical composition of this diorite have been detailed on page 90.

The rock possesses rather better rift and general working qualities than are usually associated with members of the diorite family. Fairly large blocks have been quarried and dressed for monumental and decorative purposes, with effects equal to the best grey granite. An average specimen of this diorite, on being tested, showed a water-absorption of 0·254 per cent. of its weight, in 150 hours; this result compares favourably with those afforded by the best granites.

The steep slopes of Moehau Range, besides being in general covered with a heavy layer of surface débris, are, moreover, heavily bushed. This renders it impossible to estimate the extent of the rock in question. Further exploitation, however, will probably prove that there exists a considerable amount in a condition suitable for quarrying. All of the stone quarried up to the present has come from the coast-line some 60 chains north of Darkie Creek, but prospecting operations are said to have revealed its existence at a point on the hillside further south. The quartz diorite is exposed in many of the creek beds in this vicinity, and therefore the discovery of outcrops of the rock is not a difficult matter. The location, however, of the rock in a fresh condition is not so easy, for considerable areas have been affected by hydrothermal action. Pyrite is a common secondary mineral, and its oxidation-products give rise to rusty stainings, which render even the hard rock unsuitable for decorative purposes.

Should further exploitation at the quarries prove that considerable amount of stone exists, the motive power of some of the adjacent high-grade creeks might be made available for operating stone-cutting saws. A block of stone submitted to a sawing test exhibited surfaces showing little or no pluck structure, and it seems certain that the installation of sawing machinery on the quarry property would effect a saving in the cost of production.

Pumiceous Tuffs and Breccias.—Rocks of quite a different character to that just described, and having a commercial value as building-stones, are some of the pumiceous tuffs and breccias occurring in the vicinity of Mercury Bay.

The particular type of these rocks which possesses the greatest strength and durability is the pinkish-grey compact tuff or fine-grained breccia forming the headland extending north from the Ferry Pier and bordering the eastern side of Whitianga Harbour (see page 86). The rock is favourably jointed for quarrying, and is in a splendid position for shipment and transportation to the Auckland market.

Large cuboidal blocks of the rock were employed in the construction of the Ferry Pier and in the foundations of the old sawmill on the east side of Whitianga Harbour. The stone in these structures, after some twenty-five years' exposure to the weather, is still in an excellent state of preservation, the tool-marks, as McKay* notes, "being yet almost as keen as when the rock was first cut into or dressed." A test showed that this tuff absorbed water to the extent of 15·600 per cent. in 150 hours. A somewhat similar rock to that found in the vicinity of the Ferry Pier forms the hills in the vicinity of Trigonometrical Station V, on the western side of the harbour. A very small expenditure might show that a considerable amount of marketable stone exists in this locality.

A white pumiceous fine-grained tuff, closely resembling the Oamaru limestone, but rather softer, forms Whitianga Rock and other conspicuous cliffs on the eastern side of the harbour. This rock, which splits and saws easily, and is often remarkably free from joints, might be found applicable for special purposes. It has already a reputation for withstanding satisfactorily the action of a moderate heat, and in this connection has been used for the linings of bakers' ovens, and other similar structures. Reference has already been made (page 85) to the property this rock possesses of forming a hard white siliceous skin on surfaces exposed to the weather.

The occurrence of massive rhyolite, consisting almost entirely of spherulites, has been noted. The fresh specimen of this rock indicates that it would take a good polish, and might serve for an ornamental stone. More than a surface examination, however, is necessary to determine whether a considerable amount of undecomposed rock of this class exists in an accessible locality. Some of the hills in the vicinity of Purangi Estuary present possibilities in this connection.

Rock for Road-making.—In many localities the igneous rocks possess considerable value as furnishing a plentiful supply of rock for road-making purposes.

* C. 9, 1897, p. 69.

CHAPTER IX.

MINERAL VEINS.

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Introduction.

The Coromandel subdivision of Hauraki owes its importance as a mining-area exclusively to the occurrence of gold-silver veins. Complex sulphide ores, in which lead and copper form the valuable metalliferous content, have been mined in a desultory manner from certain claims in Petote Creek, but the total value of the few tons of this ore exported is economically insignificant. This is the only instance, in the subdivision, of ores having been exploited for metals other than gold and silver.

The veins occur in the sedimentary complex forming the basement or floor of the area, and in the Tertiary volcanics of the "First" and "Second Periods" which overlie these sedimentaries. There is evidence to show, however, that the veins associated with the basement sedimentaries are genetically related to, and dependent upon, the Tertiary andesitic eruptives. The veins vary in dimensions from mere thread-like partings to strong well-defined "reefs" exceeding 60 ft. in width. The experience of the past has shown, however, that, as far as mining operations have been extended, the larger occurrences are not payably auriferous. The field has been noted for its ore-shoots of the bonanza type, the rich vein-material designated in local mining terminology "specimen stone," and valued at "ounces to the pound," having contributed far more to the total gold-output than ore valued at "ounces to the ton." As is the general rule in veins of this type, faults, cross-courses, cross-veins, and mineralised bands, as well as the character of the wall-rock, have all exercised an important influence on the position and value of the ore-shoots. Much of the information respecting the characteristics of the veins and their environments must unavoidably be expressed in rather general terms in the present bulletin. The examination of underground conditions was precluded by the temporary cessation of pumping operations in the case of all those mines working below the ground-water level, and by the discontinuance of mining operations in the case of most of those mines which may be styled "water-free."

Periods of Mineralisation.

The metalliferous veins of the Coromandel subdivision appear to be referable to at least two distinct periods of mineralisation. The earlier veins are in the main associated with the Tertiary volcanic rocks of the "First Period," but are also found in the Jurassic and Pre-Jurassic sedimentaries. These veins occurring in the mining-areas of Coromandel Township, Waikoromiko, and elsewhere do not extend into the younger andesites (Beeson's Island Series), which in these localities flank the older volcanics; hence they were evidently formed before the eruption of the younger andesites.

To this period of mineralisation may be ascribed the veins of all the mining-areas lying to the west of the main mountain divide; those of the Tokatea Hill, Success Hill (Kaipawa), and other localities on the main divide; and those occurring within the belt of "First Period" volcanics, extending from Matamataharakeke to the Upper Mahakirau Valley on the eastern side of the mountain divide.

Veins formed during the second period of mineralisation are apparently confined to certain areas on the eastern side of the main range. They occur in the andesites of the Beeson's Island Series at

PLATE XXIX.

Summit of Tokatea Hill, showing the Harbour View Mine, Old Prospecting-drives, etc.

[*Photo. by W. Beattie and Co., Auckland.*

[*To face p. 98.*

Materangi, Murphy's Hill, Owera, and Moewai, all situated on the inner portion of the Kuaotunu Peninsula, and in the basement sedimentaries at the main Kuaotunu mining centre. With these should possibly be correlated the " Silver Lode " of Tangiaro Creek, Port Charles, occurring near the contact of the " First " and " Second Period " volcanics. The veins of both the first and second periods of mineralisation, whether occurring in the basement sedimentaries or in the neighbouring volcanics, are due to similar causes. It is evident that they were formed by the ascent of heated mineral-bearing waters during the solfataric periods succeeding and connected with the extrusions of the volcanics. Since the andesites of the " First Period " were the results of several eruptions separated in certain cases by relatively long intervals of quiescence, the time-range of the earlier period of mineralisation was probably considerable, and therefore the veins may not all be contemporaneous. This appears to be exemplified in the Kapanga Mine, Coromandel (see page 66), where the andesitic tuffs of the upper and lower mine-levels are separated by an old land-surface, and each of the two horizons is said to be intersected by independent veins.

A few quartz veins occur in the dyke-intruded sedimentary rocks of the Moehau Range, but have yielded no ore of commercial value. The age of these occurrences is as uncertain as that of the intrusives, and need not be further considered.

The Circulation Channels or Vein Fissures.

The openings which afforded the channels for the circulation of the mineralising solutions, and formed the depositaries of the vein-materials, were in the main fairly well-defined fissures, but not infrequently sheeted zones or complex fractures of rather poor definition. The cause of this fissuring is not far to seek in a region which exhibits sedimentary rocks largely intruded by dykes, and overlain by volcanic rocks extruded at various time-intervals. Some of the vein-fissures, and most likely those of greater persistence, are due to faulting ; but the amount of movement is difficult to determine in the case of the altered volcanic rocks, owing to the absence of points on the opposite sides of the fracture-plane, which can be correlated. In addition to the evidence afforded by striated slickensides and selvages, faulting in the vein fissures can be inferred from its frequency in the case of the post-mineral fractures, where displacements of 30 ft. to 40 ft. are in places observable. In the stratified rocks of the Royal Oak Mine (Tokatea) displacements of strata to the extent of a few feet were observed by the writers, even in connection with some of the minor veins.

In addition to fissures of faulting, others, it would appear, were due to the contraction of the eruptive material, or to minor stresses caused by the still-existing volcanic energy. These openings can have little or no extension into the underlying basement sedimentaries ; hence the veins formed in them are likely to " give out " in depth.

Within the mining centres fissures are exceedingly numerous, the dominant ones in any particular locality showing a general parallelism ; the minor ones being disposed parallel to the larger or junctioning with them at various angles. The map (page 110) of the veins and faults of the Hauraki group of mines shows the complexity of the rock-fracturing in an area which has been characterized by great mineralisation. Generally speaking, the vein fissures of the Coromandel subdivision show a preference for strikes approaching the meridional rather than the latitudinal direction. Since the general strike of the basement rocks also approaches north and south there may be more than a casual connection.

It is difficult to speculate as to the age of the fissuring in any locality. Some of the vein fissures intersecting breccias are such sharp well-defined breaks that it would seem impossible that they could have been formed prior to the consolidation and considerable alteration of the rock. The vein fissures in the Pre-Jurassic rocks of the Royal Oak Mine were certainly formed after the intrusion of the porphyrite dykes, but, whereas the veins are certainly Tertiary, these particular dykes may be of considerably greater antiquity.

The fissures naturally vary in character according to the nature of the rocks they intersect. The principal veins of the Hauraki group of mines, intersecting, in the main, altered massive andesites, are very sharply demarcated from the wall-rock. These veins often present a somewhat lenticular form, due apparently to fault-movement along slightly sinuous fractures. Small " horses " and angular frag-

ments of country rock broken from the walls and cemented in the vein-material are not uncommon features. In the less-altered massive andesites of the Coromandel mines, and the similar phases of the grits and argillites of the Kuaotunu mines, the fissures show considerable contraction in width, and are, to use the miners' expression, " pinched."

The hard porphyrite dyke of the Royal Oak Mine, which is intersected by the " Tribute leader," shows conditions of fracture analogous to the comparatively impervious and unaltered andesite. The vein on its course through the dyke is either a single band of greatly reduced width, or is represented only by a few small stringers. The fissures in the breccias, as already intimated, appear to be regular and well defined, or erratic and poorly defined, according as to whether they were formed before or after the consolidation and considerable alteration of these rocks.

The Mineralising Agents.

The mineralising agents which circulated in these fissures were evidently aqueous solutions, as judged from the character of the vein-material and the nature of the alteration of the wall-rocks. That these solutions were hot, and in the main ascending, there is also little reason to doubt; they were evidently active during the periods of solfatarism which marked the closing phases of certain manifestations of vulcanism.

As to whether these waters were of meteoric or magmatic origin is at the present time one of the debatable questions of ore-genesis. It may be here remarked that a detailed survey of the Rotorua hydrothermal region immediately to the south of the Hauraki Division, should throw some light on this subject. The fact has, however, already been noted* that hot-spring and geyser action at Rotorua has more than a fortuitous dependence on the rainfall and general hydrostatic conditions.

Rock-alteration connected with Mineralisation.

In all mining-fields in which mineral veins are associated with andesites, an alteration of these rocks to a propylitic or similar facies is a characteristic phenomenon. The andesites and dacites of the vein-bearing areas of the Coromandel subdivision offer no exception to the general rule, and have been profoundly altered by an active circulation of thermal waters. The nature of the alteration which these rocks have undergone, although not agreeing exactly with the propylitic facies determined by Rosenbusch, has for convenience' sake been termed " propylitic " in a previous chapter. (See page 74.)

The conditions of mining existing in the Coromandel area during the years 1906–7 did not admit of the investigation of the various transitions and phases of rock-alteration which undoubtedly exist.

The most extensive vertical section through altered andesites in a vein-bearing locality is that afforded by the Kapanga shaft (1,000 ft.) and the borehole sunk from the bottom of this shaft for a further depth of 225 ft. It is stated that a pronounced alteration of the andesitic rocks to a bluish-white pyritised kaolinic-like mass obtained for a depth of some 400 ft. from the surface. Silicification is not an uncommon feature of this alteration, and many of the blebs of quartz that have sometimes been regarded as the remnants of the primary quartz of a dacitic type of andesite, are probably secondary products. This upper 400 ft. has proved essentially the zone of the rich bonanza ores. From the 400 ft. to the 900 ft. level the andesites penetrated were harder, and of a dark-greenish colour; alteration in this zone apparently resulting mainly in the development of chlorite and, in a lesser degree, of carbonates. The veins which in the highly propylitic rock of the upper zone were rich in the precious metals were here found to be contracted in width, and either barren or of very low grade. Below the 900 ft. level exists another zone of propylitic andesites, which continues to and beyond the greatest depth exploited (1,225 ft.). The limited amount of development-work done at the 940 ft. level yielded pockets of bonanza ore, smaller in extent but comparable in richness with those occurring nearer the surface.

In the Hauraki group of mines analogous conditions obtain, but the barren zone of chlorite-carbonate(?) alteration, which underlies the highly propylitic productive zone, has not been completely

* J. Malcolm Maclaren: *Geological Magazine*, vol. xiii, 1906, p. 511.

penetrated. It is stated, however, by mining-men formerly connected with the Hauraki Mine that excavating in the shaft, to provide for a "sump" below the deepest mine-level (400 ft.), revealed a gradual change from the hard dark-greenish rock to a phase simulating that of the productive upper zone.

The reasons for this zonal arrangement or stratification of the country rock showing the different phases of alteration are, in the absence of accurate data, not very evident. The old land-surface (coaly seam) encountered in the vicinity of the 940 ft. level in the Kapanga Mine might suggest a period of solfatarism with attendant rock-alteration and vein-formation in this locality prior to the accumulation of the overlying andesites. This would account for the highly propylitic rock of the lower levels of this mine underlying the darker-coloured, less-altered rock. There is no evidence, however, to suggest that similar conditions can be held to account for the alternating zones which are considered to exist in the Hauraki Mine. Whether such zones are due to alternations of rock of greater and lesser permeability, or are capable of some other explanation, must for the present remain an open question. The solution of the problem has a decided economic bearing, as these are essentially the productive and non-productive zones of this goldfield.

The acidic tuffs and tufaceous mudstones interstratified with the Pre-Jurassic argillites and grauwackes (Tokatea Hill Series) are the rocks enclosing the auriferous veins of the Royal Oak and other mines of the Tokatea Hill. These pyroclastic volcanics and the sedimentaries have been altered by the same agencies which have effected the propylitisation of the andesites. The rocks have assumed a light colour and have been considerably silicified and impregnated with pyrite, but as their original character is obscure it is impossible to more precisely determine the nature of the alteration.

The grits and argillites of the Manaia Hill Series (Jurassic) are the rocks associated with the auriferous veins of the Kuaotunu mining centre. Owing to the great amount of andesitic and rhyolitic detritus which enters into the composition of the rocks, the altered product closely resembles the propylitic andesites. The highly altered and productive zone of the upper mine-levels at Kuaotunu gave place at greater depths to a much less altered phase of the same rocks, this change being attended with a contraction in width and an impoverishment in value of the veins.

The rock-alteration already described in somewhat general terms is that attendant upon change of level. If, however, the vein fissures are regarded as the focal planes from which thermal waters and vapours were diffused throughout the wall-rock, lateral transitions from highly altered to comparatively unaltered rock might be expected. Mining operations have disclosed such lateral transitions. The country rock separating two veins approximately parallel with each other has, in certain instances, been found to grade laterally from the vein-wall, where it assumes a highly propylitic facies, to a median rib of dark and only slightly altered rock. These ribs or dyke-like masses are the "hard bars" of the miners. In some cases, however, these "hard bars" are probably due to dykes (see page 111). Such a uniform lateral transition as that described is, however, the exception rather than the rule. In the Four-in Hand Mine large spheroids of hard, dark rock, showing only a minor amount of alteration, are encountered in and near the actual vein fissure; again, in the same mine dark and only slightly altered massive andesite in places forms the rock on the hanging-wall side of the vein, while rock primarily the same, but now light-coloured and highly altered, constitutes the rock extending for a considerable distance from the foot-wall.

In addition to rock-alteration proceeding from vein fissures, other areas of highly altered andesite, in which no veins have been detected, would appear to be explainable only as the result of a general rise of thermal waters through the main mass of the rock. More especially is this likely to have occurred where the volcanic accumulations were at the time of solfataric action of a readily permeable character.

Mineralogy of the Ore and Gangue Minerals.

The veins of the Coromandel subdivision can hardly be said to afford a great variety of minerals, although a list covering all the occurrences that have from time to time been identified is somewhat lengthy.

Quartz, and to a lesser extent pyrite, invariably constitute the main gangue-minerals of the gold-silver veins. Calcite is not an infrequent vein-constituent, and occasionally equals in bulk the quartz with which it is associated. Galena, chalcopyrite, and the alteration-products of the latter mineral become abundant in certain lenses of the veins, near or at the contact of igneous and sedimentary rocks. A low gold-content, however, appears to characterize all these galena-chalcopyrite ores. Stibnite to an amount of 13·5 per cent. of the ore occurs in some of the unexploited veins of the Mahakirau district. The prominence attained by the various other minerals will be gauged approximately from the descriptions which follow.

The minerals detected from time to time during the course of mining operations have been the subject of notices by previous investigators, and on these notices the writers of the present bulletin have largely drawn.

Non-metallic Minerals.

Quartz.—Quartz is the chief gangue-mineral in all the veins, both as fissure-filling and to a lesser extent as the result of silicification of the wall-rocks. It is generally finely crystalline, or, again, is crystallized in small prisms terminated by pyramidal faces, the colour in either case being white or bluish white. Transparent quartz crystals of considerable beauty often occur in the veins at Opitonui and Tokatea on the walls of some of the larger geodes or vugs. Much of the quartz of the Kuaotunu area is milk-white, and exhibits the platy or laminated structure usually attributed to pseudomorphism after calcite. Rhombohedral cells, lined internally with fine drusy quartz, are fairly common, and are evidently due to the replacement of portions of the original calcite, and the removal of the remainder by solution. In other portions of these veins in which the platy quartz occurs, cellular, saccharoidal (" sugary "), and occasionally banded quartz are found.

Amorphous and Cryptocrystalline Silica.—Chalcedony, carnelian, and jasper are common in minor fissures in the argillites, and occasionally in the volcanic rocks. Siliceous sinter forms veins in the rhyolites of Purangi and in certain areas of the Beeson's Island tuffs. It has also great development as terraces and pipes in the Waitaia Ridge, Kuaotunu, and elsewhere.

Calcite.—Calcite occurs as rhombohedra, scalenohedra, hexagonal prisms, and various modifications of these forms. It is in colour generally milky-white, sometimes colourless, and occasionally yellow ; the latter coloration is due probably to iron-oxide.

As regards the occurrence of this mineral, Maclaren remarks, " Iceland spar is common in the Tokatea Mines, perfect crystals up to half an inch being obtainable. In the colourless varieties, however, the cleavage-planes are so visibly abundant as to render the crystals valueless for Nicol's prisms, &c. . . . Dogtooth and nailhead spar in scalenohedra are common in Scotty's Reef in the Kapanga area. Argentine, a pearly lamellar calcite, is found in the Tribute Reef, Tokatea." *

Aragonite.—Aragonite is found in stellate needles in Scotty's Reef (Kapanga).

Mirabilite, or Glauber's Salts.—The hydrous sulphate of soda (Glauber's salts) occurs in minute quantities in old drives and workings.

Epsomite.—Epsomite, the hydrous sulphate of magnesium, occurs as an efflorescence, in the form of long rhombic silky prisms, on the walls and roofs of old drives and workings. It is referable to the alteration of wall-rock rather than of vein-material.

Kaolin.—An undetermined kaolinic product — the " pug " of the miners—is fairly abundant in the reefs. In part it probably results from the decomposition of the feldspathic constituents of the wall-rocks, and in part from an extremely fine comminution of the wall-rocks along planes of movement.

Metallic Minerals.

Gold.—The gold of all the veins in the area under review occurs in association with silver as an electrum. The proportion of gold to silver in the bullion derived from the average ores by the amalgamation process varies from 1 : 0·75 to 1 : 0·30. The greater percentage of silver present in the bullion

* C.-9, 1900, p. 16.

obtained from the same ores by a solvent (cyanide) process or by fire assay indicates that not all of this metal is alloyed with the gold. In the great majority of the payable ores the electrum occurs as a dissemination of coarse metallic particles or filaments, and less frequently of particles in such a finely divided state as to be almost invisible to the unaided eye. Visibly crystallized gold (electrum) has been frequently detected in the Tokatea area; but the crystals are generally very imperfect, showing as a rule only a single edge or face. A rather perfect specimen, however, known locally as "the golden butterfly" was discovered some years ago in the Rainbow Reef, Tokatea, and has been described by Maclaren. The specimen, this writer remarks, "is probably unique in possessing a form composed of the cube, octahedron, and rhombic dodecahedron."*

Silver.—The occurrence of silver as associated with gold has already been described. Argentiferous galena also occurs, but in small quantities.

Argentite (Silver-glance).—Argentite as bluish-black bands is the principal ore-mineral of the "Silver Lode," Tangiaro Creek, Port Charles, and occurs sparingly in some of the quartz veins of the Matawai Valley, Waiau. The mineral apparently occurs in the massive form; no crystal-outlines have been identified.

Pyrargyrite (Ruby-silver).—The occurrence of small cochineal-red crystals of pyrargyrite in a vein of the Golden Pah Mine, Coromandel, is reported by Maclaren.

Kerargyrite (Horn-silver).—Several pounds' weight of the chloride of silver, kerargyrite, are reported to have been obtained some years ago from the Waikoromiko Valley.

Cinnabar (Sulphide of mercury).—The presence of cinnabar is reported by J. A. Pond from various parts of the Hauraki Peninsula—Coromandel, among others—"but in no instance is it present in large or well-defined quantities."† No indication is given as to the actual locality of the specimen.

Pyrite (Disulphide of iron).—Pyrite is, next to quartz, the mineral of most widespread occurrence in the veins of this goldfield. It occurs as cubes and pyritohedrons, and in the massive state.

Marcasite (White iron-pyrites).—Marcasite has been found associated with pyrite in the veins of the Matawai Valley and elsewhere.

Mispickel (Arsenopyrite—Sulphide and arsenide of iron).—Mispickel occurs in association with pyrite and stibnite in the veins of the Matawai, Mahakirau, and Umangawha Valleys, and the garlic odour which this mineral emits when struck with steel is frequently observed in the mines of the Kapanga and Hauraki groups.

Melanterite, or *Copperas* (Sulphate of iron).—Melanterite, as an oxidation-product of pyrite, has been observed forming small stalactites in the mines of the Hauraki and Kapanga groups.

Ilmenite (Oxide of iron and titanium).—The occurrence of massive ilmenite as rolled pebbles in the Waikoromiko Creek has been reported.‡

Hæmatite (Oxide of iron).—Hæmatite forms pseudomorphs after calcite in the Try Fluke vein, Kuaotunu. Earthy forms of this mineral in association with limonite are of general occurrence.

Limonite (Hydrous oxide of iron).—Hydrous oxides of iron are common, as oxidation-products of pyrite, in the gossanous weathered portions of the veins.

Native Copper.—Native copper has been found as small grains associated with the chalcopyrite in the veins of Petote Creek (Coromandel), also very sparingly in some of the ore of the mines of the Kapanga and Hauraki groups.

Chalcopyrite (Copper Pyrites—Sulphide of copper and iron).—Chalcopyrite is fairly abundant in some of the veins, especially those occurring in or near the basement sedimentaries.

Bornite, or *Erubescite* (Sulphide of copper and iron).—Bornite is found forming an iridescent film on chalcopyrite in the veins of Petote Creek and elsewhere.

* C.-9, 1900, p. 15. † C.-3, 1887, p. 58. ‡ C.-9, 1900, p. 17.

Malachite (the Green carbonate of copper).—Malachite is found as an alteration-product wherever chalcopyrite occurs.

Azurite (the Blue carbonate of copper).—Azurite occurs under the same conditions as malachite.

Tetrahedrite (Sulphide of copper and antimony, with silver, &c.).—Tetrahedrite is reported to have been identified from a vein occurring in Koputauaki Bay.

Galena (Sulphide of lead).—Galena is of fairly common occurrence in the veins occurring in or near the basement sedimentary rocks. It is argentiferous, but not highly so.

Hedyphane (a variety of Mimetite—Lead arsenate and chlorate).—The occurrence of mimetite, in which the greater part of the lead is replaced by calcium, is reported by Maclaren from certain clayey partings in the basement sedimentaries.

Sphalerite, or *Zinc Blende* (Sulphide of zinc).—Sphalerite occurs in association with galena and chalcopyrite in the veins of Petote and Tiki creeks.

Nickel.—Cox * refers to a " foliated serpentine " from Coromandel having yielded a trace of nickel.

Native Arsenic.—Native arsenic occurs in several of the mines on the Tokatea-Kapanga-Hauraki auriferous belt. In the West Tokatea and other mines situated just to the south of Tokatea Saddle, the arsenic usually takes the form of reniform nodules. The mineral on exposed surfaces is of dull-black colour, but on fresh fractures exhibits its characteristic greyish-white metallic lustre. Geodes exceeding 6 in. in diameter are not uncommon, and often enclose filaments of gold. In the Kapanga Reef arsenic as reniform nodules and in massive forms has been observed, while in the Hauraki North reefs the mineral generally occurs massive.

Arsenolite (As_2O_3), *Orpiment* (As_2S_3), *Realgar* (AsS).—The oxide and sulphides of arsenic were noted by Maclaren from Tokatea Hill " as an incrustation on the exposed wall of a reef." †

Arsenopyrite.—See Mispickel (page 103).

Antimonite, or Stibnite (Sulphide of antimony).—Stibnite occurs granular, or as rhombic prisms arranged in spine-like or stellate form, in several veins of the upper Mahakirau Valley. Analysis of some of the vein-material has shown the presence of an amount of stibnite equivalent to 9·66 per cent. of antimony. The mineral also occurs in the veins of the Matawai Valley, and to a lesser extent in the veins of the Hauraki Freehold and Blagrove's Freehold Mines.

Kermesite ($Sb_2S_3 + Sb_2O_3$).—Kermesite, according to Maclaren, occurs in cherry-red fibrous crystals as an incrustation on the reef in the Hauraki North Mine (now Hauraki Freehold).†

Native Bismuth.—A fragment of native bismuth discovered in the gravels of Wade Creek (Mahakirau) a few years ago led to a certain amount of prospecting for this mineral. The source of the detrital fragment was, however, not located.

Tellurium.—Apparently the only reference to the occurrence of tellurium within the subdivision appears to be in a paper by F. B. Allen, formerly Director of the Thames School of Mines. The notice is as follows : " Tellurium has been found by the author (among other places) at Coromandel. . . . Quartz containing 25 per cent. mispickel : Assay—200 oz. gold per ton, 90 oz. silver per ton. This ore contained a little tellurium, the amount of which was not estimated. A considerable quantity of the ore was roasted without loss of bullion."‡ The writers of the present report have not been able to ascertain the actual locality from whence this quartz was derived.

Pyrolusite and Wad.—The black oxides of manganese, pyrolusite and wad, occur frequently though never in great quantity in the veins of the subdivision. These minerals, imparting a black stain to the vein-quartz, are characteristic of Tokatea Hill, Kuaotunu, and Materangi.

Rhodonite and Rhodochrosite.—The presence of rhodonite and rhodochrosite, the silicate and carbonate of manganese, is indicated by the amethystine coloration which the quartz and calcite of the veins occasionally present.

* Trans., vol. xiv, 1881, p. 436. † C.-9, 1900, p. 17. ‡ *New Zealand Mines Record*, vol. iv, 1901, p. 469.

By Authority: John Mackay, Government Printer.

Structure of the Vein-material.

The larger structures of the veins, being dependent upon the character of the fissures, will be inferred from a previous section (page 99). Only the arrangement of the various minerals within the fissures need be here described.

The majority of the Coromandel veins, and especially those of economic importance, range from 2 in. to 10 in. in width and are in general characterized by a very vuggy structure, although compact vein-filling often occurs.

The mineral material deposited from the circulating solutions first formed crusts on the fissure-walls. These crusts, which themselves contain numerous small vugs, gradually grew outwards from the walls in rather irregular fashion, sometimes uniting to form a solid sheet or again leaving open spaces or larger vugs between them. These larger vugs, while often arranged along the medial planes, may again, on account of irregular crust-growth, be found to show no definite arrangement in the vein. Like the smaller ones they almost invariably show drusy linings.

Although these vugs are in the main small, they occasionally attain large dimensions. In the Tokatea and Tribute veins of the Royal Oak Mine, these cavities sometimes exceeded 10 ft. in length and a foot in width, and are often lined with very beautiful incrustations of quartz and calcite. The less coarsely crystalline quartz forming the main mass of the vein-material between these large vugs and the wall-rock was, in certain cases, very highly auriferous. In the much larger vein of the Maiden Mine, Opitonui, some great vugs lined throughout with perfectly formed projecting quartz crystals were encountered.

Vein-material showing well-defined banded or ribbon structure is scarcely ever found in the veins of the Coromandel centre, although it has been occasionally observed in those of the Kuaotunu field. An indistinct banding, rendered evident only by the higher percentage of pyrite in certain parts of the vein-stone than in others, is noticeable in some portions of the more compact material. This feature was the more evident when the darker pyritic bands were highly impregnated with gold, as in Legge's Reef in the Hauraki Mine.

The Tokatea Big Reef consists in the main of crystalline quartz containing small drusy cavities, and in places shows sheeted structure. The foot-wall of the vein is sharply demarcated from the wall-rock, but the hanging-wall is poorly defined, metasomatic replacement of the andesites being apparent. In the Try Fluke veins, Kuaotunu, hollow rhombohedral cavities and platy or laminated structures due to replacement after calcite, characterize the greater bulk of the quartz. Saccharoidal or "sugary" quartz may be due in part to crushing by rock-movement of the friable vein-material, in part to a leaching-out of calcite originally deposited in intimate association with the quartz.

Minor structures of the vein-material will be noticed in connection with the detailed description of individual veins.

Oxidation.

At and in the vicinity of the vein-outcrops the ore, owing to oxidation of the pyrite and iron-bearing minerals generally assumes a rusty-brown colour and gossanous appearance. The depth to which this oxidation along the veins extends is very irregular, but usually exceeds that of the general oxidation of the country rock. The ground-water level of the area cannot now be ascertained, owing to the existence of the numerous old adits which effect the drainage of the mining claims. It is certain, however, that the general level of rock-oxidation did not correspond with that of the ground-water. Adits are being driven at the present time in highly pyritised rock showing no sign of oxidation, and these are at levels considerably above that of the original ground-water. Again, country rock stained throughout with limonite has been encountered at a considerable depth below the water-level. The physical characters of the rocks, and the presence or absence of fissures, appear to be the main factors governing the vertical extent of the oxidation-zone.

In the vein-outcrops, as the result of the usual oxidation processes and removal of soluble salts, the following minerals are by far the most abundant: quartz, limonite, manganese-dioxide, and brown-

stained kaolinic material. With these occur the gold and silver as an electrum, the ratios of the two metals differing little from that obtaining in the deeper portions of the veins. In the chalcopyrite-bearing veins the carbonates malachite and azurite are the usual minerals of the zone of oxidation.

The Ore-shoots.

The payable ores in the auriferous veins are disposed as shoots or patches—tabular masses of more or less definite outline. If the necessary data were available, the mapping of the veins of the various notable ore-shoots discovered in this mining-area would be interesting and instructive, but no opportunity was afforded of studying these occurrences.

The pitch-length of these shoots generally exceeds their breadth. The largest of the Hauraki Mine bonanzas extended from the surface to a depth of about 260 ft., measured from 120 ft. to 150 ft. in breadth, and about 8 in. in average thickness. This shoot had a pitch at high angles to the northward. The ore-shoots of all the approximately parallel Hauraki veins occurred in corresponding positions in the veins, and pitched in the same direction as the main shoot. This is the structure termed in the older mining phraseology " ore to ore," or shoots " back to back." In the Iona No. 2 vein of the same mine the shoot occupied a nearly horizontal position, and occurred at about 60 ft. below the original water-level. Where the vein was small (5 in. to 6 in. wide) the bonanza ore formed the whole of the vein-stone ; where the vein increased in width to 3 ft. or 4 ft. this rich ore often formed about 6 in. on the hanging-wall side, the remainder being of very much lower grade.

The factors which have exerted the greatest influence on the position of the ore-shoots are (*a*) intersections—namely, " flatheads," carbonaceous seams, faults, cross-courses, dykes, ; (*b*) the nature of the country rock ; (*c*) depth.

The effect of intersections on the value of the ores, particularly the rich bonanza ores, is a well-established fact on this field. At the intersections of cross-veins, flinties, and " flatheads," the mingling of waters that have come from different sources, or, travelling *via* different directions, have acquired different characters, has resulted in precipitation of the gold and its associated minerals. The precipitation in the vicinity of the carbonaceous seams, of pyrite, and with it gold and silver, owing to the powerful reducing action of carbon, is evidenced in the Kapanga and other mines. Further reference to this action will be found later (page 117). Faults and cross-courses may have influenced precipitation in the vein-channels by the supply of precipitating-solutions, but in many cases appear to have determined separate systems of circulating ground-waters. In the majority of cases which have come under the notice of the writers, the rich bonanza ore occurred in the veins on the upper or hanging-wall side of the fault. This would appear to indicate that, locally, at any rate, the waters were descending. In certain cases in the Hauraki Mine the ore-shoot terminated on the hanging-wall side of a fault, and yet fragments of rich bonanza ore were found in the fault-fissure between the two displaced ends of the vein. This would appear to be explainable only by assuming that the gold was deposited subsequent to the formation of the fault, and that a later movement along the fault-plane had dragged in portions of the bonanza ore previously formed.

In the Royal Oak Mine the fact that a porphyrite dyke of greater age than the veins limited the ore-shoot will be mentioned in connection with the detailed description of this mine.

The influence of the country rock on the ore-shoots has already been described to some extent in connection with rock-alteration. In certain cases rock-alteration is evidently an accompaniment rather than a cause of the deposition of heavily mineralised ore. There are evidences, however, that a general rock-alteration and mineralisation sometimes preceded the formation of even the vein fissures, and in such cases this altered country rock would have its effect on subsequent ore-deposition. It would seem that the physical character of the original rock has been perhaps more important in this connection than its chemical character.

Considering that all the important ore-shoots discovered in this area have been mined from within 800 ft. and mostly within 400 ft. of the present land-surface, irrespective of its topography, the factor of depth is of paramount importance. Viewing the facts broadly, the theory of secondary enrichment by the generally accepted processes of dissolution, migration, and redeposition of the metalliferous

contents of the veins attendant upon a gradual denudation of the land-surface seems the most plausible hypothesis. If the extent to which denudation has taken place since the veins were formed could be gauged even roughly, the question would be greatly simplified ; but no such estimation seems possible. From lack of opportunity, the writers cannot claim to have made a study of the paragenesis of the ores. It may be stated, however, that neither the mode of occurrence nor the character of the rich bonanza vein-stone is comparable with that of the highly enriched ore occurring in districts where " sulphide enrichment " by descending waters is known to have taken place. There are no perceptible transitions from the bonanza ores to lean sulphide ores. Furthermore, in the deeper horizons of the shoots the ores are generally equal in richness to those of the outcrops and upper levels ; these shoots when followed down on their pitch frequently give out suddenly, and are replaced by vein-material similar in general character, but containing practically no trace of gold or silver. Ore-shoots of lesser extent have in places been found to succeed in depth the larger shoots of the upper horizons.

It would appear that proximity to the original surface has been favourable to the deposition of the high-grade gold-silver ores. The theory that the precipitation of these metals takes place at " critical levels " under the varying conditions of temperature and pressure would therefore receive some support from the occurrences on this field.

Origin of the Gold and Silver.

The solution of the problem as to the origin of the gold and silver in the ores appears to depend largely upon the accurate chemical analyses of an adequate number of samples of the ores and the altered and unaltered rocks of the area. The most numerous and reliable analyses yet recorded of the Hauraki Peninsula rocks are those cited by Dr. Don* from the soft decomposed and the hard, dark andesites of the Moanataiari Mine, Thames. Briefly stated, these analyses indicate that gold and silver do not occur in unaltered andesites, but occur to a greater or lesser extent in all these rocks containing secondary pyrite. The results of these analyses are in accord with those obtained by Don from the rocks of other goldfields of New Zealand and Australia, and have led this investigator to the conclusion that " the gold of many lodes of the chief mining districts of New Zealand, Victoria, and Queensland is not due to lateral segregation from the adjacent country rock, but to solutions ascending from some rock deeper than any now exposed at the surface in any part of these colonies." That writer adds, " I am not concerned with the question whether this source is the vague ' barysphere ' with its somewhat apocryphal contents of heavy minerals. I have simply to note that a series of laborious and careful examinations has failed to find it in the rocks of the ' lithosphere.' "

During the course of the present survey certain volcanic and sedimentary rocks from Coromandel mining-areas were collected by the writers and submitted to the Colonial Analyst for examination. These results, which are withheld until further rocks from the Thames subdivision are collected and examined, are in confirmation of the investigations made by Dr. Don.

Distribution of the Veins.

From the maps it will be observed that mineral veins are of fairly general occurrence throughout the subdivision. They are found in certain localities in the Jurassic and Pre-Jurassic stratified rocks, abundantly in the " First Period " volcanics, and only on the eastern side of the main range in the " Second Period " volcanics. With the " Third Period " rhyolites are associated only siliceous sinters, having no value as ore-deposits.

Although quartz veins are of such widespread occurrence, mining operations have shown that nearly all the more highly auriferous veins occur within the limits of certain fairly well-defined belts.

(*a*.) The most important auriferous belt in the whole subdivision is that extending from north of Kevin Point (on the shore of Coromandel Harbour) to and beyond Tokatea Hill and Saddle. This belt, which has a trend in an approximately north-north-easterly direction and a width of about a mile, includes the Hauraki, Kapanga, and Royal Oak groups of mines, and has therefore produced the greater part of the gold of the Coromandel field.

* J. R. Don : " The Genesis of certain Auriferous Lodes," Trans. Am. Inst. Min. Eng., vol. xxvii.

(*b*.) A parallel belt of lesser importance is that lying about a mile to the south-east of the one described. This extends from Preece's Point on the shores of Coromandel Harbour through the Success and the Old Whangapoua Claims on the main range, to the Four-in-Hand Claim in Kopurukaitai Valley.

(*c*.) A definite belt or zone of mineralisation, but one which has so far afforded no payable mines, is that extending from the Moewai Mine, Ngarahutunoa Valley, north-north-east through the Owera, Murphy's Hill, and Materangi Ridge Claims.

(*d*.) The Kuaotunu belt of mineralisation, covering the Bald Spur and Waitaia Ridge areas, has a trend similar to the last-named (*c*), and its southerly continuation is probably represented in the minor auriferous occurrences of Whauwhau Creek.

The auriferous areas of the Tiki Hill, Manaia Valley, Opitonui, and the upper Mahakirau Valley are not included in any of these belts, and appear to be more isolated. The two first-named of these particular areas show considerable lithological resemblances, and would, moreover, fall on a north-east – south-west belt.

The existence, strike, and parallelism of these belts is rather significant, and attention has already been drawn to the most important of them (*a*) by the writings of McKay and Maclaren. The reason for such a disposition is not very evident. The prevailing strike of the basement sedimentaries has been shown to vary approximately from north-north-east to north-north-west, so that the zones of mineralisation may in certain cases correspond approximately to the strike of these strata. Such a correspondence of mineralisation with general stratification-lines has been observed in Westland.* Apart from whether or no such agreement exists in the Coromandel area, the assumption that the gold has been derived from deep-seated rocks (see page 107) would imply fracture and fissuring of the basement sedimentaries now exposed or underlying the andesites along these north-north-easterly belts.

Detailed Description of Special Areas.

VEINS OF THE COLVILLE SURVEY DISTRICT.

In the Colville Survey District no metalliferous veins were located during the course of this survey, nor does an examination of the stream-débris favour the opinion that such exist.

An analysis from certain small stringer veins exposed on the western coast-line some 30 chains north of Goat Bay gave negative results for gold and silver.

VEINS OF THE MOEHAU SURVEY DISTRICT.

In the Moehau Survey District the geological formation is similar to that of Colville, and the veins located are few and unimportant.

Hope Creek.—A vein, which has in the past received some attention, occurs on the north-western slope of Hope Creek Valley, at an elevation of 630 ft. The old adits are in a state of collapse, and little information can be gleaned as to the size and character of the vein. It would appear, however, that it occurs in indurated argillites at or near the contact of an intrusion of porphyrite. The course of the vein is about east–west and its dip at high angles to the northward. Its width is not determinable, but blocks of quartz ranging up to 2 ft. appear on the "dump." Like most of the contact veins of the subdivision, the vein-material contains pyrite, galena, and sphalerite. A sample collected from the "paddock" yielded on analysis,—

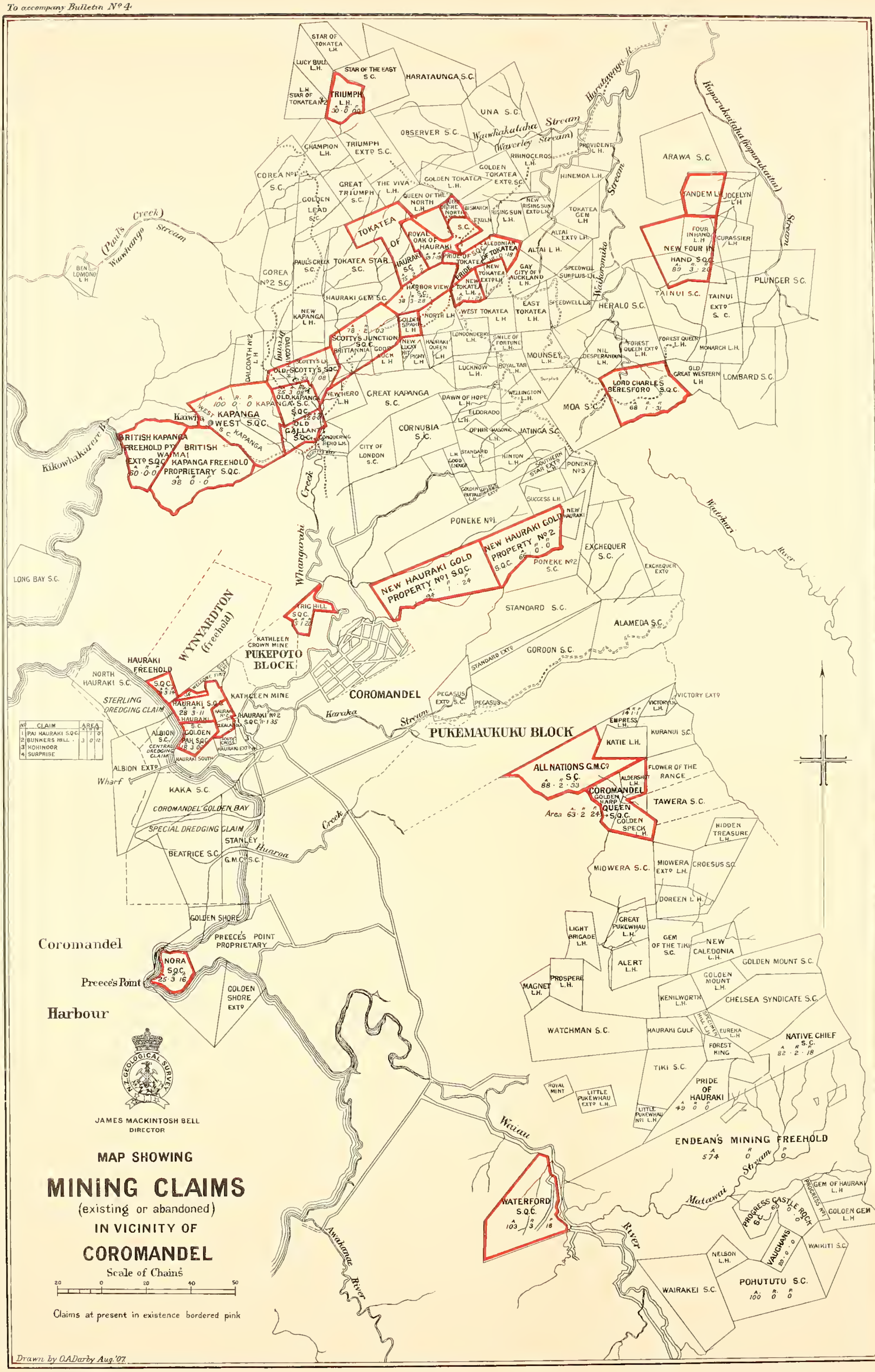
	Per Ton. Oz.	dwt.	gr.
Gold	0	1	6
Silver	9	14	8

Value, £1 9s. per ton.

Sorry Mary Creek.—In Sorry Mary Creek a small irregular quartz vein, sparsely impregnated with similar sulphides to those occurring in the Hope Creek vein, is seen at the contact of intrusive andesite

* See Reps. G.S., Bulletin No. 1 (New Series), Bell and Fraser, 1906, p. 96.

To accompany Bulletin No 4.



By Authority. John Mackay, Government Printer, Wellington.

with argillite, about 20 chains from the coast-line. Analysis, however, showed the vein to be of no commercial value,—

	Per Ton. Oz. dwt. gr.
Gold	0 0 1
Silver	0 0 15

Ohinewai Creek.—Near the head of Ohinewai Creek large quartz boulders occur as "shoadings" on the north-western slope of the valley and within the area of altered porphyrites. The quartz is coarsely crystalline, and does not bear a favourable appearance for the existence of valuable metals. Analysis indicates a gold-content merely to the amount of 5 gr. per ton.

Ongahi Creek.—This creek showed no quartz veins, but the grauwacke occurring at the contact of a dioritic intrusion was so highly silicified and pyritised that samples were collected for analysis. The result, however, which is as follows, is of scientific rather than of economic interest :—

	Per Ton. Oz. dwt. gr.
Gold	0 0 2·5
Silver	0 2 5
Lead	0·005 per cent.

A highly altered and pyritised andesite from a lower elevation in the same creek yielded on assay,—

	Per Ton. Oz. dwt. gr.
Gold	0 0 1
Silver	0 0 15

VEINS OF THE HARATAUNGA SURVEY DISTRICT.

The veins of the Harataunga Survey District are numerous, occurring both in the argillites and grauwackes of the Moehau Series, and in the andesites and rhyolites of the "First Period." While certain of these veins have yielded small pockets of highly auriferous ore, in no case have they afforded remunerative returns to any of the companies or private individuals that have exploited them. According to official statistics, the total value of the gold-silver returns for twenty-five different claims for the period 1887–1906 did not exceed £3,000.

On the general map the positions of nearly all the known veins have been located, and to only certain of these need reference be made in the following description.

Vein of Tangiaro Creek.—In Tangiaro Creek, flowing into Port Charles, a vein is exposed at an elevation of 75 ft., and at a distance of about a mile and a quarter from the coast. Its course is north-west – south-east, and its dip westward at a high angle. The vein, which is enclosed in a mottled grey propylitic andesite, has been drifted on 4 ft. or 5 ft. ; it is well defined and shows a width of 42 in. The vein-material is, where exposed, nearly all oxidized to a yellowish-brown colour, but unaltered bands and patches are preserved. These show quartz containing, in addition to disseminated pyrite, streaks of finely divided metallic sulphides, including argentite. The general character of the ore is unlike that observed elsewhere in the Coromandel subdivision, and resembles rather that occurring in certain veins of the Great Barrier Island, some twenty-five miles to the northward. A general sample taken by the writers yielded on analysis,—

	Per Ton. Oz. dwt. gr.
Gold	0 0 22
Silver	19 1 5

Value, £2 1s. 9d. per ton.

Ore of much higher grade apparently exists, since McKay in referring to this occurrence remarks, "Samples of stone taken from a lode 3 ft. to 4 ft. thick have been analysed both at the Thames School of Mines and at the Colonial Laboratory, Wellington, the yield in both cases being from 105 oz. to 110 oz. of silver, and from a trace to 17 dwt. of gold to the ton." *

It is a matter for surprise that no systematic attempt has yet been made to prospect this vein.

* C.-9, 1897, p. 57.

Veins of the Umangawha Valley (Cabbage Bay).—Within the Umangawha Valley the country drained by the Ngakuku, with its branches the White Star and Jersey Creeks, encloses the quartz veins of the Harataunga Survey District, which have during recent years received most attention.

In the White Star Gully the White Star and Killarney veins, striking north-north-west and north-east respectively, are the most important yet located. The former averages about 6 in., and the latter some 3 ft. in width, both being enclosed in a light-coloured altered rhyolite showing conspicuous phenocrysts of quartz. With the vein-quartz is associated pyrite and arsenopyrite.

The gold, to the value of about £1,000, obtained by the companies that worked the claim was in the main derived from a small steeply pitching shoot in the White Star vein, at its intersection with a small stringer. A large quartz vein carrying, it is stated, a little gold, has been intersected in the lowest (No. 3) mine-level. The Jersey vein, averaging only about 3 in. in thickness, occurs some 20 chains to the north-eastward of the White Star, and also intersects rhyolites. A gold-silver return valued at £209 is recorded from 10½ tons mined from the latter vein during the years 1897–99.

In Ngakuku Creek several quartz veins varying from 1 in. to 2 ft. in width are exposed at intervals in the andesites, for over a mile above the last outcrop of argillites. Pyrite and arsenopyrite are disseminated throughout the vein-quartz. Of six samples submitted for analysis it is significant that none of them gave negative results for gold and silver. The gold ranged from 4·5 gr. to 2 dwt. 12 gr. per ton, whilst the silver-content varied from 3 gr. to 1 dwt. 21 gr. per ton. The particular vein showing the highest value (10s. 2d. per ton) trends nearly north-south (see map), and varies from 6 in. to 12 in. in width.

Having regard to the general mineralisation of the veins and the alteration-phase of the enclosing andesitic rock, Mr. Allen who examined this area, considers that further prospecting is warranted.

A vein of some 10 ft. in width, intersecting argillites of Ngakuku Creek, and distant about 20 chains from the junction with the Umangawha, yielded on analysis,—

	Per Ton. Oz.	dwt.	gr.
Gold	0	0	15
Silver	0	0	15

Value, 2s. 6d. per ton.

On the northern slope of Austral Hill, at the bend of the Umangawha Valley, several small veins associated with altered rhyolite have been worked in a desultory manner. The veins in these rhyolites are less well defined than those in andesites, and are frequently represented only by numerous thin parallel stringers. The gold-silver content generally occurs as small isolated "pockets."

Veins of Matamataharakeke.—In the watershed draining into Waikawau Bay—generally known as the Matamataharakeke district—prospecting operations have been carried out intermittently for some years past. The auriferous veins located in Cousin Jack and Gisborne Creeks, and in Macaronic Gully (Waikanae Creek) have all proved of very small dimensions and unreliable as gold-producers. The "First Period" andesites—namely, tuffs and breccias—constitute the country rock, and a few "colours" of gold can be obtained in the creek-débris by panning.

The analysis of a sample from the vein mapped in Matamataharakeke Creek, which is about 16 in. in width, is as follows:—

	Per Ton. Oz.	dwt.	gr.
Gold	0	0	19
Silver	0	0	19

Veins of Mangatu Creek.—Three small veins occur as mapped in Mangatu Creek (Kennedy's Bay). A sample assayed from the most westerly occurrence showed,—

	Per Ton. Oz.	dwt.	gr.
Gold	0	1	21
Silver	0	1	6

Value, 7s. 7d. per ton.

The remaining two each contained only a few grains of gold and silver per ton.

Veins of Mataiterangi Creek and Bay View Mine (*Kennedy's Bay*).—Numerous quartz veins, varying in width from a few inches up to 10 ft., occur in both headwater branches of the Mataiterangi Creek, These veins all occur in an altered andesitic breccia, and, although in some cases pyrite is abundant, no gold was detected either by "panning-off" tests or by analysis.

The Bay View Mine, situated near the crest of the range (elevation 780 ft.) at the head of the Mataiterangi, was worked intermittently from 1887 to 1899, the value of the gold and silver raised being only £156. The veins, which have been mined from four small adits, range up to a foot in width, and are associated with what appears to be an altered tufaceous andesite. The payably auriferous ore is stated to have existed only as small isolated patches.

Veins of Omoho Creek.—A small quartz vein exposed in the bed of the Omoho Creek (flowing into Kennedy's Bay) near the crest of the main range falls within the Harataunga Survey District. This vein, which intersects dark thin-bedded argillites, ranges in width from zero to 4 in. or 5 in., and shows in places gold associated with the pyrite and slaty selvages. Prospecting operations have resulted in a gold-silver return valued at about £100. The hardness of the rock, however, renders the exploitation of this narrow lenticular vein expensive.

VEINS AND MINING CLAIMS OF THE HAURAKI SPECIAL AREA.

Locality and General Features of the Area.

A ridge of low hills with rounded outlines fringing the north-eastern shore-line of the Coromandel Harbour, and the low alluvial flat skirting the base of these hills, is the *locus* of the Hauraki group of mines. These hills attain a general elevation of 250 ft., and are clothed with a somewhat sparse growth of stunted scrub.

Geological Formation.

The rocks of this special area, which have vertical extension to and beyond the greatest depths yet attained in the mine-workings, are essentially massive and pyroclastic andesites and dacites of the "First Period." Associated with these effusives is at least one dyke-intrusion. This dyke—a hornblende porphyrite—is probably referable to the "Second Period" of vulcanism. It has been located in the workings of the Golden Pah Mine, and probably its northerly extension accounts for the "hard bar" existing in the levels driven south from the Union Beach shaft of the Hauraki Mine.

The greater part of the rocks constituting this mining-area is highly propylitised. The "country" considered of most favourable character, as being usually associated with the rich ore-shoots, is light-grey in colour, with a faint bluish tint, only moderately hard, and more or less impregnated with fine granular pyrite. The "hard-bars" of mining terminology are in most cases merely remnants of less-altered rock, but occasionally, as in the case of the "bar" mentioned in the Golden Pah Mine, they owe their existence to intrusives. The veins and faults, both of which are numerous, will be considered in connection with individual mines of this particular area.

Mining Claims.

The principal mining claims of the special area (see Map, page 108) are the Hauraki and Bunker's Hill, the property of the Old Hauraki Gold-mines (Limited); the Welcome Find and Hauraki North, the property of the Hauraki Freehold Company (Limited); and the Golden Pah, Hauraki No. 2, and Hauraki South, held by private individuals or syndicates.

The Hauraki and Bunker's Hill Mining Claims.

The Hauraki and Bunker's Hill mining claims, the property of the Old Hauraki Gold Mines (Limited), adjoin each other, and are on the same or closely allied veins. The claims occupy a central position in the group here considered, and their boundaries and relative positions are shown on the accompanying map (page 108). The area of the Hauraki Claim is 28 acres 3 roods 11 poles, and that of the Bunker's Hill 3 acres and 12 poles.

The total value of the gold-silver obtained from these claims up to the 31st December, 1906, as compiled from official and other reports, is as follows :—

Hauraki Mine—	
By Telephone Gold-mining Company (from Union Beach section)—	£
1871 to November, 1875	25,000 (estimated)
November, 1875 to 1885	61,245
,, Coromandel Gold-mining Company, 1886 to 1894	459
,, Hauraki Gold-mining Company (from Hauraki section), 1894 to 1903	293,572
,, Old Hauraki Gold-mining Company, 1903 to 1906	6,196
,, proprietors of tailings plant	742
Bunker's Hill Mine—	
By Bunker's Hill and New Bunker's Hill Gold-mining Companies, 1895 to 1906	17,017
	404,231

The dividends paid—	£
By Telephone Gold-mining Company totalled	32,000
,, Hauraki Gold-mining Company (London), including bonuses, totalled	188,000
,, Old Hauraki Gold-mining Company totalled	1,250
,, Bunker's Hill Gold-mining Company totalled	1,333
	222,583

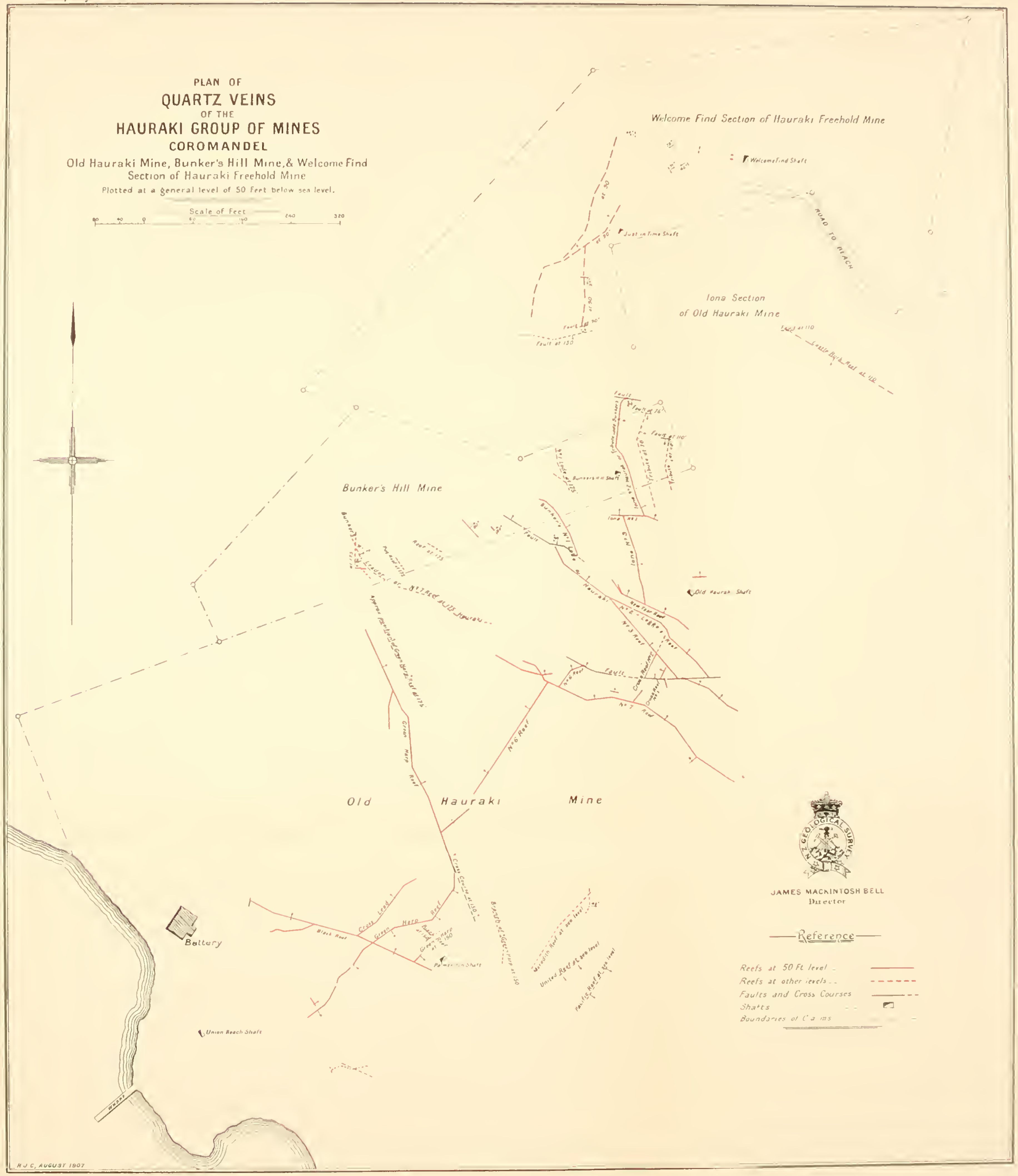
Mine Development and Equipment.—Access to the underground workings of the Hauraki and Bunker's Hill Claims is afforded by three main openings, known respectively as the Hauraki, Union Beach, and Bunker's Hill shafts. The Hauraki shaft (size 12 ft. by 8 ft.) has a collar-elevation of 60 ft. above sea-level, and a vertical depth of 420 ft ; the equipment consists of a Cornish pump of 12 in. diameter, and winding-cages, all operated by steam - power. The Union Beach shaft (12 ft. by 8 ft.), located on the foreshore of the harbour and 1,070 ft. westward of the shaft already described, has a collar-elevation of 5 ft., and a total depth of 200 ft ; equipment consists of winding-appliances and a disused pumping-engine. The Bunker's Hill shaft (11 ft. by 3 ft. 6 in), located 230 ft to the north-west of the Hauraki shaft, has a collar-elevation of 125 ft., and a total depth of 290 ft. ; equipment consists of a winding-engine, cages, and accessories.

The main working-levels from the three shafts mentioned, having been driven by different companies, are not on corresponding horizons. From the Hauraki shaft five levels give access to the workings ; the depths of these levels below the shaft-collar are 100 ft. (40 ft.), 160 ft. (100 ft.), 220 ft. (160 ft.), 300 ft. (240 ft.), 400 ft. (340 ft.), the numbers in parenthesis indicating the depth of each level below high-water mark. From the Union Beach shaft the two levels driven have depths of 80 ft. (75 ft.), and 180 ft. (175 ft.). From the Bunker's Hill shaft three levels have been extended at depths of 140 ft. (15 ft.), 210 ft. (85 ft.), and 270 ft. (145 ft.) respectively.

From the main working-levels extended to intersect the veins the latter are exploited and mined by the usual methods of driving and stoping.

The ores raised are all free-milling, and the gold fairly " coarse." The mill on the Hauraki Claim consists of a fifteen-stamper battery, Wilfley vanner, berdans, and accessories. The motive power employed is steam.

The Veins.—An examination of the plan (Map. page 112) will at once indicate that mineralisation in the Hauraki and Bunker's Hill Claims has proceeded along numerous lines of rock-fracture, presenting a rather complex arrangement. The majority of the veins strike in directions varying from north–south to north-west–south-east, and have a prevailing dip to the east or north-east. Others, however, present strikes more or less transverse to those mentioned. Although the formation of all the vein fissures would not appear to have been actually contemporaneous, the data available scarcely permit



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of any generalisations. The "Cross Lead" and "No. 6 Reef," which are considered identical and preserve a north-east – south-west course, would appear, from displacements effected by the transverse system of veins, to be one of the oldest lines of fracture. The course of the "Green Harp Reef," however, one of the most persistent in the whole area, is peculiar in that it bends round almost at right angles, at first exhibiting conformity in strike to one set of veins and then to the transverse set of veins. This fact would appear to suggest that mineralisation, if not rock-fracturing, had been contemporaneous, or nearly so, throughout this particular area. The nature of the mineralisation, if this be any criterion, also supports this conclusion.

The veins vary in dimensions from mere stringers to strong ore-bodies 4 ft. or 5 ft. in width; but the majority have an average width of 3 in. to 9 in. They are in almost every case sharply demarcated from the wall-rock, and would appear to be the result of the filling of narrow fissures formed by faulting or contraction. The actual vein-walls are frequently smooth and slickensided, being separated from the wall rock by a narrow selvage of plastic finely comminuted rock (locally termed "pug"). Occasionally, owing to a local collapse of the walls of the fissures, brecciated rock, subsequently cemented by vein-material, has resulted. "Horses of mullock" may be due to the same cause, or to an initial local duplication of the fissure-fracture.

The primary gangue minerals of the veins are essentially quartz and pyrite. Others which have been observed, but only as sparsely distributed constituents, are calcite, hydrous oxides of manganese, and arsenopyrite. The quartz is usually compact, finely crystalline, and of a bluish-white colour. Drusy cavities lined with small prisms of quartz, terminated by pyramidal faces, are abundant. The pyrite which has been deposited contemporaneously with the quartz is usually finely granular, that occurring in the druses either granular or cubical.

The gold present in the ore is invariably associated with silver as an electrum, containing on the average 74 per cent. of gold and 26 per cent. of silver by weight. This corresponds roughly to the formula Au_3 Ag_2 (Au_6 Ag_4). In almost all the payable ores, whether they are in a state of oxidation or not, the gold is visible megascopically. It usually occurs as coarse jagged particles or dichotomously branching filaments throughout the general mass of the quartz.

The payable ore of these mines occurs in the veins as shoots or pockets, variable in extent and disposition. In these bonanzas, ore worth "three ounces to the pound" (that is, ore containing 3 ounces (troy) of gold per pound advoirdupois) is not uncommon, and many tons of ore have been won, averaging over "an ounce to the pound." The general mass of the vein-material associated with bonanzas and lying within the limits of the ore-shoots is payably auriferous, while that of the vein beyond the limits of these shoots is either non-auriferous or so low in gold-content as to be of no commercial value.

The north-west – south-east trending veins and branch veins—namely, "Legge's" (No. 1, Bunker's), "New Year," "No. 3," "No. 7," and "Green Harp," show a general agreement in the disposition of their ore-shoots. These shoots, though differing considerably in extent, nearly all exhibit a pronounced pitch to the north-west. A line drawn at right angles to the general trend of the vein-system, at a certain point would intersect many of these bonanzas, hence the phenomenon described as "ore to ore" is here well exemplified.

The greatest ore-shoot yet discovered in these claims was that of the No. 2 or "Legge's Reef." This shoot measured 150 ft. in width, and extended from the surface of the solid propylitised andesite to a depth of about 260 ft. Its pitch to the north-west corresponded to the inclinations of the intersections of the No. 3 vein and the "Cross Reef No. 2." The intersecting veins, veinlets, and cross-courses have exercised an influence not only on the position of the great ore-shoot of this vein, but on that of the shoots and pockets of bonanza ore in each of the veins. The occurrences of the various patches of rich ore in both the "Green Harp" and the "No. 6" veins aptly demonstrate this influence of intersecting veins and fissures on the deposition of the gold. Between these planes of intersection long stretches of the veins have been allowed to remain intact, as unpayable to exploit, although there is, of course, no certainty that other shoots remain undiscovered in these particular blocks.

The north–south-trending vein, "Iona No. 2," of the Hauraki Claim has in part been termed the "Iona No. 3" on the mine-plans, owing to displacement by a fault-fissure, and is further known as

the " Tribute Lode " in the Bunker's Hill Claim. The vein has been traced for a total distance of 340 ft., passing from the Hauraki Claim through the Bunker's Hill and into the Welcome Find Claim. It varies from a few inches to 4 ft. in width, and dips at an angle of 40° or less. The vein differs from the others of the area only in its low inclination and in the general horizontality of the discovered ore-shoot. This shoot occurred at a depth of some 40 ft. below sea-level (100 ft. below the collar-level of Hauraki shaft), and continued throughout the whole exploited length of the vein. This ore-shoot, unlike those of most of the other veins of the system, was unaffected either in horizon or in tenor by a fault-fissure (" Iona No. 1 ") which caused a 35 ft. horizontal displacement of the vein. A fault with a southerly hade in the vicinity of the north-east corner of the Bunker's Hill Claim has here terminated this consistent gold-bearing vein. This faulting has effected a considerable " drag " of the vein to the eastward, a fact which sufficiently indicates where its displaced portion should be found.

The No. 7 and " Green Harp " veins of the Hauraki Claim would appear to have junctioned in the Bunker's Hill Claim. At and in the vicinity of this intersection bonanza ore was discovered, and is reported to have continued as a nearly vertical shoot to and beyond the greatest depth exploited.

The Faults.—The post-mineral or non-mineralised fractures are in this area almost as numerous as the veins. They are in almost all cases fissures filled, as the result of rock-movement and decomposition processes, with clayey material (" pug "). Frequently they afford very effective barriers to the circulation of the ground-waters, or, again, are more open and permeable.

The main faults, it will be observed from the map (page 112), show a general parallelism and a north-west – south-east strike. Those existing to the north of the Bunker's Hill shaft hade to the south-west, those to the south of the shaft hade to the north-east. This would suggest step-faulting, both from the north and the south towards this shaft. It would seem certain, however, from the displacements of the veins that each successive block of country, considered in order from south to north, has been displaced to the eastward. A recognition of this fact has an important bearing on the recovery of " lost " veins.

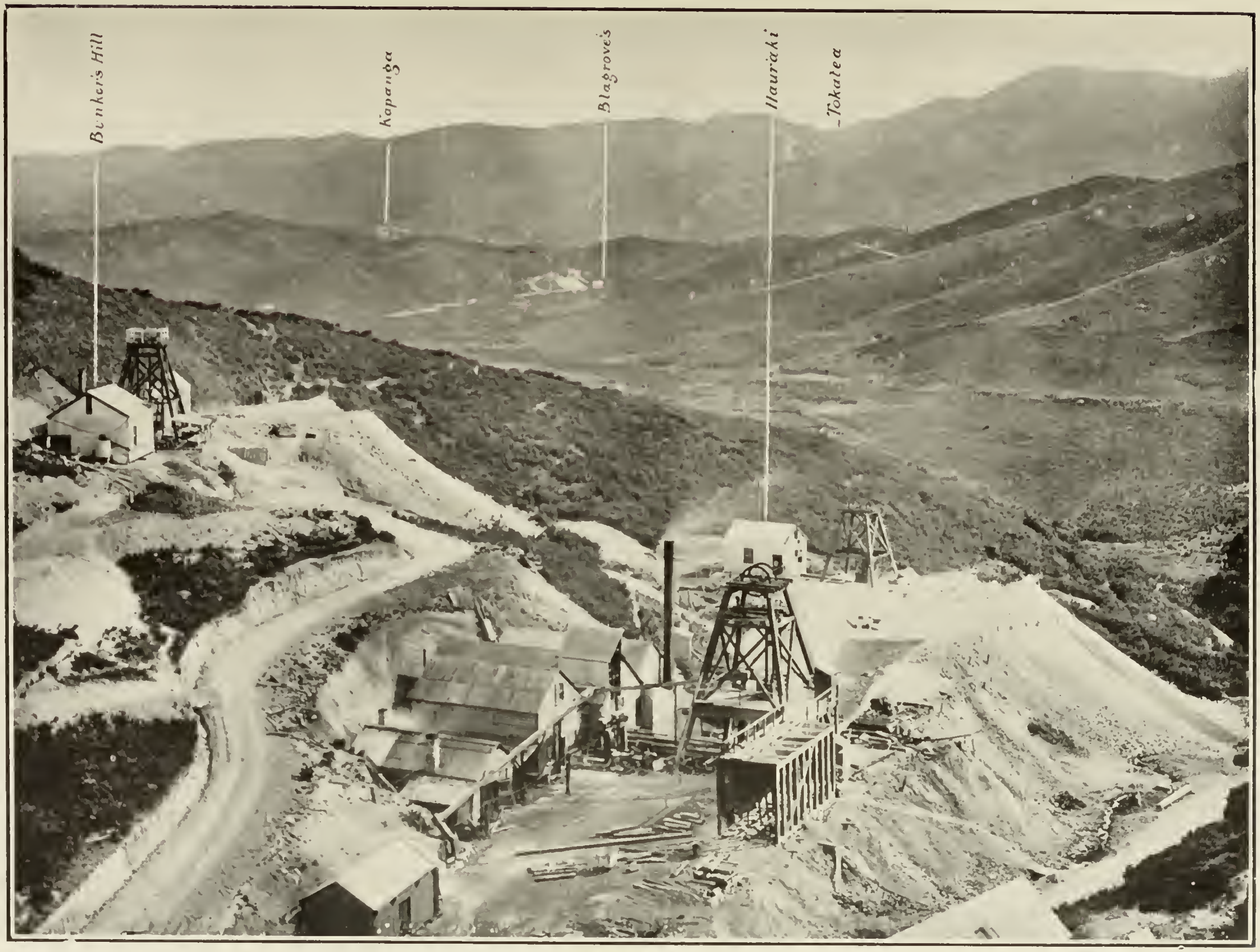
Future Development.—An expression of opinion as to the directions in which future mining operations might be extended with a reasonable hope of success, must, in the absence of more specific data, be based on somewhat general considerations.

The advisability of the further exploitation of " Legge's," the " Hauraki No. 7," and the " Green Harp " veins below the present workings of the Bunker's Hill Mine may be suggested. This follows on a consideration of the probable northerly dip of the productive propylitic zone of the Hauraki Mine and of the pronounced pitch of the exploited bonanza ore-shoots in the same direction. The successive downthrows to the north-east of the several faulted blocks of " country " lying to the north of the Bunker's Hill shaft also favour the prospect of " deeper ground " on this propylitic zone in the locality indicated.

The recovery of certain veins which carried high-grade ore, and were abruptly terminated by faulting, would also appear warranted. Chief among these is the Iona No. 2 vein, which on the north side of the fault should be found in the Iona section of the Hauraki Mine.

As in all mining properties of this particular character, the policy of advancing prospecting cross-cuts through the relatively large undeveloped areas in the proved zone of mineralisation cannot be too strongly recommended.

It is a matter for surprise that in an area which has yielded bullion to the value of over £400,000 the deepest workings have attained no greater depth than some 400 ft. below the present caps of the veins ; this notwithstanding that bonanza ore comparable with that obtained from the surface-levels has been mined from a depth of nearly 300 ft. Quite irrespective of the results which may attend further mine-development in the upper propylitic zone, the sinking of the Hauraki shaft in the hope of intersecting another ore-bearing horizon is certainly a legitimate prospecting proposition. There is every likelihood that the andesites of these and the neighbouring mining claims will extend to considerable depths, judging by the conditions obtaining in the Kapanga Mine, which is nearer the outcrops of the basement sedimentaries.



Eastern Section of the Property of the Old Hauraki Gold-mines (Limited), showing also the Positions of the Kapanga, Blagrove's and Tokatea Mines.
[*Photo. by W. Beattie and Co., Auckland.*

[*To face p. 114.*

The Welcome Find Claim and Hauraki Freehold.

The Welcome Find Claim and the Hauraki Freehold, which are together held by the Hauraki Freehold Company (Limited), lie to the northward of the two claims just described. Map, page 108, shows the relative positions of these mines; map, page 112, on an enlarged scale, the Welcome Find Claim (area, 8 acres 1 rood 8 poles) and its principal veins.

The principal access to the underground workings is afforded by two openings—the Welcome Find and the Hauraki North shafts. Equipment on the former shaft comprises a small Cornish pump and a pair of winding-cages, operated by steam-power; that on the latter shaft, a pair of winding-engines operated by a rather meagre water-power.

The greater part of the gold-output of these claims is referable to the early days of the field. Since 1895 the value of the gold and silver won amounts to £8,898.

The greatest depth to which mining operations have been advanced in these claims is 230 ft. below the surface. In the Welcome Find Mine two other levels exist at elevations of 60 ft. and 100 ft. respectively above the low level.

The veins, together with the occurrences of the pay-ore, differ in no respect from the general type of those in the Hauraki and Bunker's Hill Claims, and must be regarded as belonging to the same system. Faulting is here, as in the adjoining claim, a prominent feature, and has the usual influence on the position of the ore-shoots. Precise information as to existing economic conditions in these mines was not available to the writers, on account of a temporary cessation of mining operations. The suggestions made in respect to future operations in the Hauraki and Bunker's Hill Mines, however, have a general applicability to the mining-claims here considered.

The position of the claims, their areas, and the results which have from time to time attended the operations already carried out, warrant further exploitation on the present levels, and in the unknown areas of greater depths.

Golden Pah, Hauraki No. 2, and Hauraki South Mining Claims.

The Golden Pah, Hauraki No. 2, and Hauraki South Mining Claims all lie in the southern portion of this special area. Maps, pages 108 and 101, show the claim-boundaries and the veins that have been mapped. The total gold-output of the claims is small, but the actual figures are not available. Access to underground workings is afforded by adits and shafts; but the latter are in a state of disuse, and the machinery has in most cases been dismantled.

In the Golden Pah Claim certain veins have at times afforded small pockets of rich bonanza ore, while oxidized propylitic andesite containing numerous reticulated quartz veins has been mined from certain localities above the ground-water level, and milled for its gold-content.

In the Hauraki No. 2 Claim a considerable amount of work has been done from adit levels. Veins probably identical with certain of those in the Hauraki Mine have been prospected, but no ore-shoots of any importance have been located.

In the Hauraki South Claim a fairly substantial shaft was sunk some years ago by an English company, but little prospecting-work below the ground-water level was undertaken. The rock encountered in the shaft itself did not exhibit the phase of alteration usually associated with the payably auriferous veins of the Hauraki group of mines.

THE VEINS AND MINING CLAIMS OF THE KAPANGA SPECIAL AREA.

Locality and General Features of the Area.

The Kapanga special area is located among the foothills of the western base of the Tokatea Hill, and lies nearly midway between the Hauraki area already described and the Tokatea area to be considered later. This foot-hill country, covered with a stunted growth of manuka and fern, varies in elevation from 200 ft. to 300 ft., and is incised by several small tributaries of Whangarahi Creek.

Geological Formation.

Tertiary andesites and dacites of the "First Period," in the form of tuffs, breccias, and lava-flows, constitute the rocks of this area to and beyond the greatest depths yet exploited. The general disposition of these volcanics and the various zones of propylitic alteration have already been described (see page 100). The relatively great depth to which the andesitic rocks have been proved to extend in the Kapanga shaft has occasioned some surprise in view of the fact that the basement sedimentaries outcrop within 50 chains of the shaft. A movement of subsidence has, however, been recorded in the Kapanga area by the coal-seam existing at a depth of 940 ft. below the present surface (700 ft. below sea-level). On the supposition that this movement was a differential one, due to faulting along the western base of Tokatea Hill, the relative positions of the volcanics and the older rocks is readily explainable. The extraordinary pressure of the ground that was encountered in the sinking of the Britannia shaft, at the western base of Tokatea, would also suggest the presence of a fault in this vicinity.

Between the Kapanga area and Kikowhakarere Bay, lying to the westward, the "First Period" volcanics—auriferous series—are flanked and overlain by the rocks of the Beeson's Island Series, which, both here, and wherever encountered on the western side of the peninsula, are non-auriferous.

Mining Claims.

The principal mining claims of this special area are the Old Kapanga, the property of the Old Kapanga Gold-mining Company (Limited), and the Old Scotty's, the property of the South Kapanga Gold-mining Company (Limited). Other areas of lesser importance are held by these companies and by private individuals.

The Old Kapanga Claim.

The Old Kapanga Mining Claim (area, 25 acres 3 roods 8 poles), which is now the property of the Old Kapanga Gold-mining Company (registered in Auckland), was for the thirty-four years prior to 1906 owned and worked, together with certain adjoining ground, by an English company. Map, page 108, sets forth the position of the claim, and its past and present boundaries.

The value of the gold-silver production prior to the year 1864 is not recorded. That of subsequent years, compiled from official and other reports, is as follows :—

	£
By Kapanga Gold-mining Company (Auckland), 1864–69	122,419
,, Kapanga Gold-mining Company (London)—	
1872–85	11,380
1886–90	33,461
1890–98	29,249
1898–1906	8,394
Total	204,903

The amount paid in dividends is not recorded.

Mine Development and Equipment.—Access to the underground workings is afforded by one main shaft, and there also exist two or three disused shafts connected with the upper workings. Numerous adits, now in a state of collapse, were driven from the various small gullies in the early days to exploit the veins above the ground-water level. The main shaft (size 14 ft by 9 ft.), with a collar-elevation of 240 ft. above sea-level, has been sunk to a depth of 1,000 ft. This shaft, at a depth of 520 ft. to 600 ft., intersected the Kapanga and Scotty's veins, dipping westerly from their points of outcrop some hundreds of feet to the east of the shaft's mouth.

Above these levels the veins were exploited from crosscuts driven eastward at depths of 300 ft., 420 ft., and 500 ft. respectively. In addition, drives, to which further reference will be made, have been extended at the 600 ft., 700 ft., 800 ft., 940 ft., and 1,000 ft. levels.

The machinery employed in carrying out the mining and milling operations included a 15 in. plunger and draw-lift pump, winding-equipment, and a ten-stamp battery—all operated by steam-power. The whole of this, however, was recently dismantled and removed. The present proprietary company has installed a small pumping and winding plant, to permit of certain work in the upper levels of the mine.

The Veins.—The veins of the Old Kapanga Mine comprise the Kapanga and Scotty's, with their various branches, also Hartridge's, Anniversary, and several which are not named.

The Kapanga and Scotty's veins, which have yielded nearly all the gold of this mine, show in the upper levels a general parallelism both in strike and dip. The strike of each vein is decidedly serpentine, but in general direction does not vary greatly from north–south (see map, page 118). The westerly dip varies in each case from 25° to 35°, the low angles being more characteristic of Scotty's vein. The trend of the Kapanga vein at and below the 420 ft. level, as the plate will show, exhibits variations from that of the upper levels. Below the 600 ft. level the dips of the Kapanga and Scotty's veins are at considerably higher angles than those mentioned. The change in the vein fissures from low angles to fairly high angles corresponds with the change in the country rock from fairly soft propylitic andesite to harder less-altered andesite. This would imply alternation of softer and harder rock at the period of rock-fracture, the fissures in the harder rock being deflected towards the directions of least resistance.

In the 1,000 ft. level, where the lower zone of propylitic andesite has been entered, neither the Kapanga nor Scotty's vein has been identified, although the crosscut has been advanced beyond where they were expected to have occurred. In this low-level zone were discovered Hartridge's, the Anniversary, and other veins, none of which were identified in the upper levels of the mine. These veins of the lower levels, moreover, strike almost at right angles to the Kapanga and Scotty's veins. It is impossible from the meagre data obtainable to account for this apparent unconformity in the vein systems of the upper and lower levels of the mine. In this connection, however, regard must be had to the old land-surface (coal-seam), which marks an unconformity in the andesitic accumulations, but the writers cannot definitely assert that Hartridge's, Anniversary, and the other veins terminated on their upward extension at this old land-surface.

The vein-material, which was apparently deposited in narrow, open fissures, consists in the main of quartz, pyrite, and occasionally calcite. The gold and silver, alloyed in the ratio of about 100 : 43, occurs with this gangue mainly as shoots and patches of the bonanza type. Native arsenic and arsenopyrite are common associates of the highly auriferous vein-stone. It has also been noticed, remarks Maclaren, "that a green discoloration of the country often precedes the discovery of rich quartz—a colour due probably to melanterite or iron-sulphate." *

The bonanza ores of both the Kapanga and Scotty's veins are said to have occurred at the planes of intersection of the small cross-veins, or loop-veins, and also at points of marked local irregularities —elbows and bends—in the veins themselves. Strong pyritic mineralisation of the wall-rocks almost always accompanied the richest ore-shoots. The highly auriferous ore of the Kapanga and Scotty's veins had extension, though not continuous, from the outcrops to a depth of some 450 ft. This ore, in passing from the vein-outcrops to the depth quoted, while showing diminution in quantity, cannot be affirmed to have shown diminution in gold-content.

In Hartridge's vein (9 in.) patches of bonanza ore, rather small in extent but comparable in tenor with those from veins of the upper levels, occurred at the 940 ft. level. The largest of the patches was found near the main shaft, where the vein came in contact with the flat-lying coaly seam already mentioned. The precipitation of the gold at this point was evidently effected by the great masses of pyrite, which occur in this seam as the result of the reducing action of carbon. Gold has been detected in the actual seam or "mineral bar" as isolated coarse grains in association with quartz; but an analysis of a general sample from the pyritic mass on the surface "dumps" gave negative results for gold and silver.

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* C.-9, 1900, p. 15.

Future Development.—With regard to the resources of the mining property, the available data permits only of somewhat general considerations. The Kapanga and Scotty's veins, worked for over forty years, must in the upper mine-levels be regarded as almost completely depleted of their ores; small loops and branches of these veins carrying pockets of highly auriferous quartz may, however, be discovered from time to time, as recent experiences have demonstrated. It cannot be ascertained from examination of the mine-plans to what extent prospecting crosscuts within this productive propylitic zone have been advanced. The extension of the adit level from the low grounds of Kikowhakarere Bay to the Kapanga shaft has from time to time been advocated as a means of permanently draining and opening-up for prospectors a considerable area of country, and also affording a roadway for the cheaper delivery of fuel and mining-material to the several claims. The scheme is certainly a feasible one, although no discoveries of auriferous veins can be anticipated within the belt of the Beeson's Island volcanics, which extends from the coast-line for about half a mile inland.

The hopes of the proprietary company are centred on the low levels of the mine, owing to the proved existence of the zone of highly propylitic rock extending from the 940 ft. level in the shaft to and beyond a depth of 1,225 ft. (the bottom of the borehole sunk from the 1,000 ft. level in shaft). At the 940 ft. level the limited amount of work done on Hartridge's reef has demonstrated the fact that patches of bonanza ore do exist in the propylitic zone. Again, from an unspecified level in the borehole crushed pyritic material was, during the progress of boring operations, submitted to the senior riter for analysis, and yielded gold and silver equal to a value approximating £5 per ton.

Increased depth usually implies a lesser concentration of the gold-silver content of veins. While, therefore, in the low levels bonanza ore-shoots may exist where conditions favourable to their formation have obtained, the precious metals may generally be found more evenly disseminated throughout the vein-material. The results of treatment of the ore from Hartridge's vein support this conclusion. Returns, not inconsiderable, were obtained by the ordinary battery-amalgamation process from ore from this vein which showed no visible gold. In the upper-levels, vein-material in which no gold could be seen seldom or never yielded sufficient to cover the cost of treatment.

It will be inferred from the facts submitted that further exploitation of the Kapanga Mine is desirable in the deeper horizons, which exhibit pronounced alteration of the country rock by hydrothermal agencies, with an attendant strong general mineralisation.

The ground-water conditions existing in the Kapanga Mine, as revealed by pumping operations, are of both scientific interest and of economic importance. From the original water-level to a depth of about 550 ft. (310 ft. below sea-level) the amount of water to be raised was considerable. Below the 550 ft. level it is stated the volume showed rapid diminution, and at the 1,000 ft. level, (760 ft. below sea-level), became almost a negligible quantity.

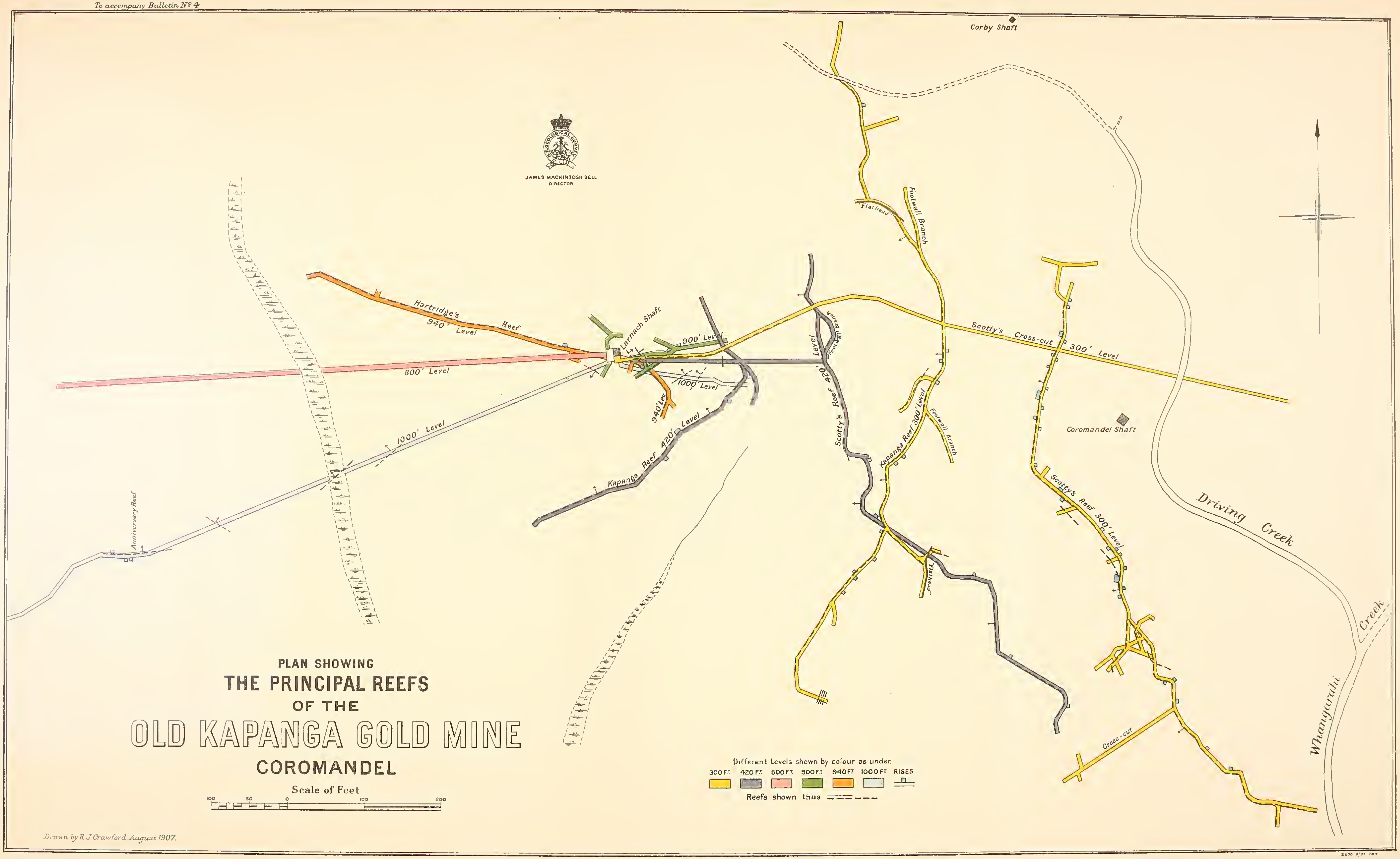
Old Scotty's Mining Claim.

Old Scotty's Mining Claim, the property of the South Kapanga Gold-mining Company, has been worked on the northward extension of Kapanga and Scotty's veins from the Old Kapanga Mine, and on minor veins closely related to these. The gold-silver returns for the earlier period of the mine's existence are not available; but for the period 1891–1906 the value of the total output only amounts to £3,520. Maps, pages 108 and 104, show the position of the claim and the veins which it encloses.

Other Areas.

The areas lying to the north-east and south of the claims mentioned enclose numerous veins, which have in former years been exploited by various companies and private individuals. Of these veins Murphy's and the Flying Cloud may be mentioned as having yielded, near the surface, patches of bonanza ore. The characteristics of these veins are in the main the same as those of the Old Kapanga Mine.

To accompany Bulletin No 4



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THE VEINS AND MINING CLAIMS OF THE TOKATEA-SUCCESS RANGE.

Locality and General Features of the Area.

The Tokatea-Success Range may be considered as that stretch of the main divide extending southward from a point 40 chains north of Tokatea Hill to the Whangapoua Saddle. The most prominent heights on the range are Tokatea Hill (1,577 ft.), Trigonometrical Station UU (1,852 ft.), and Kaipawa or Success Hill (1,935 ft.). Tokatea Saddle has an elevation of 1,200 ft. The range-flanks, which are in the main fairly steep, are incised by several small streams draining to either coast-line, and support a vegetation consisting in places of light mixed bush, and elsewhere of scrub and grasses.

Geological Formation.

As the geological map and sections will show, the basement or core of the whole of the Tokatea-Success Range consists of rocks of the Tokatea Hill Series—argillites and grauwackes, with interstratified volcanics of acidic character. These folded and denuded strata were covered by the Tertiary andesites of the "First Period"—tuffs, breccias, and lavas, the fragmental rocks predominating. These old interstratified volcanics are, owing to denudation, exposed on the actual crest of the range at Tokatea Hill and Saddle, and on both flanks of the range at certain localities. The Tokatea Hill Series in this area is largely intruded by dykes of porhpyrite, and in one locality on the eastern flank of Tokatea Hill by a dyke of rhyolite. Some of these porphyrite dykes may also intersect the overlying Tertiary andesites, but the alteration and weathering of the rocks renders detection of the dykes difficult.

Reference has already been made (page 100) to the alteration by thermal waters of the andesites (propylitisation) and of the older rocks.

The Veins.

The veins of the Tokatea-Success Range comprise (*a*) the Tokatea "Big Reef"; (*b*) the veins of the Tokatea Hill and vicinity, subsidiary to the "Big Reef" but of much greater economic importance; (*c*) the veins of Success Hill and vicinity, related to the "Big Reef," as are those of group (*b*).

(*a*.) *Tokatea "Big Reef."*

The Tokatea "Big Reef" is the largest vein occurring not only in the particular area under review, but in the whole of the Coromandel subdivision. It varies approximately from 30 ft. to 150 ft. in width; strikes about north-and-south and dips west at an angle of 45°–65°. The vein forms a conspicuous feature of the landscape, standing out in places as a white wall, and covering the slopes of the range with "shoadings" of quartz boulders. The most northerly outcrop occurs some few chains to the north of Tokatea Hill where the vein is almost coincident with the crest of the range. On tracing its course southward from Tokatea Hill the "Big Reef" descends on the western slopes of the range. At a point just northward of Courthouse Creek, where it attains probably its maximum thickness, the vein bifurcates, one branch striking south-east and the other south. The more westerly branch, or that trending south, appears to vary considerably in width, and its outcrops only appear at intervals. The most southerly outcrop is found in the bed of Cadman Creek, 6 chains above the water-supply dam, where the vein has a width of perhaps 40 ft. The branch trending south-east maintains a width averaging 40 ft. to a point some 12 chains south of the Success Road, beyond which it becomes much attenuated.

The Tokatea "Big Reef" intersects both the Tertiary andesites and the basement sedimentaries On the high western flank of Tokatea Hill and in Maddern Creek it appears to lie at or near the contact of the andesites and the strata of the Tokatea Hill Series. Further south it is almost always found associated with the andesitic rocks. This vein, however, in the No. 7 level of the Royal Oak Mine (Tokatea) and its westerly branch in Cadman Creek are both associated entirely with the argillites and grauwackes of the Tokatea Hill Series.

The vein-material is in the main the result of fissure-filling, but where the wall-rock consists of andesite the hanging-wall portion is largely the result of the replacement of that rock. White crystalline quartz exhibiting numerous drusy cavities, and containing a very small percentage of pyrite and, occasionally, hydrous oxides of manganese, constitutes the vein-filling. Sparsely distributed galena and copper-pyrite are ocasionally present where the vein occurs at the contact of andesites and argillites. The decomposition of the vein-material by surface waters has resulted in the conversion of the pyrite to hydrous oxides of iron, which impart a brownish staining to the whole mass.

The opinion has been sometimes expressed in mining circles that the Tokatea " Big Reef " has some prospective economic value on account of its gold-content, and a few trial crushings from certain points are cited as having yielded returns of from 1 dwt. to 4 dwt. of gold per ton. With the object of ascertaining its actual gold-silver content the vein was made the object of special investigation by the writers, and a careful sampling was undertaken at points which offered the best facilities. In the Tokatea area the vein is well exposed in the bed of the Whakaroa Creek, just below the " tip-head " of the Harbour View low-level. Samples selected from wall to wall of the vein, which at this point measures about 60 ft., were shown by analysis to contain no trace of gold or silver.

Further south the vein, or a branch of the vein where intersected by Courthouse Creek, showed, in addition to pyrite, a small percentage of galena and chalcopyrite. Sampling and analysis of the vein-material revealed no trace of gold or silver.

The south-eastern trending or main foot-wall branch of the " Big Reef," which boldly outcrops on Success Hill, was examined in detail on account of a prevailing general impression that at least this portion of the " Big Reef " had a potential value as a low-grade ore-deposit. The prospecting operations undertaken some years ago by an English company—the New Hauraki Gold Properties (Limited)—afforded special facilities for ascertaining the value of a considerable extent of the vein. A drive has been advanced from the Success Road for a distance of 1,200 ft. along the footwall and at a depth of some 200 ft. below the highest point of outcrop. From this drive the vein itself has been crosscut or partly crosscut at various intervals. Throughout a distance of 800 ft. from the mouth of the drive these crosscuts show the vein to have an average width of 40 ft., but from here southward a gradual " feathering out " longitudinally is apparent. At each of the twelve crosscuts heavy samples were broken out from foot-wall to hanging-wall, or (where the hanging-wall was not exposed) from the foot-wall to the end of each crosscut. The vein-material from each 10 ft. interval of these cross-sections was tested separately. Each sample was reduced by crushing and quartering, the portion not required for analysis being reserved for the ordinary " panning-off " test. As the result of these operations twenty-four samples were submitted for analysis.

	Gold per Ton. Gr.	Silver per Ton. Dwt.	Silver per Ton. gr.
1 sample yielded	2	0	13
1 ,, ,,	1	1	4
1 ,, ,,	1	0	14
2 ,, ,,	1	0	6
3 ,, ,,	1	0	3
1 ,, ,,	0	0	8
3 ,, ,,	0	0	7
2 ,, ,,	0	0	4
10 ,, ,,	No trace of gold or silver.		
24			

Panning-off tests, which in the examination of oxidized vein-material are thoroughly reliable, showed no " colour " of gold in any of the above samples. In addition to confirming the laboratory analyses, these tests showed that the vein-stuff contained no coarse grains of gold which might have escaped inclusion in the assay samples.

From a drive on the vein situated between the southern end of the main level above described and the outcrop, three general samples were selected, all of which gave nil results for gold and silver.

The southern trending or hanging-wall branch of the "Big Reef" has been crosscut in a drive from the Success Road. Three heavy general samples were broken out and sampled down for analysis. Each afforded nil results for gold and silver.

A general sample taken from the southern continuation of this branch of the "Big Reef" where it crosses Cadman Creek (width here perhaps 40 ft.) yielded on analysis—gold, nil; silver, 1 dwt. 6 gr. per ton.

The above results show unmistakably that the Tokatea "Big Reef" has, at least in the particular localities investigated, no economic value as an ore-deposit. It may be further remarked that these particular localities—Tokatea and Success—are those in which occurred the highly auriferous subsidiary veins of the system. In other words, the localities are those in which the Tokatea "Big Reef" traverses the ascertained auriferous belts.

It would appear, from the results submitted and also from an inspection of some of the underground workings, that the bulk "parcels" mined and milled from the "Big Reef" with a view to ascertaining its value by battery tests, were not representative. The bulk samples consisted almost entirely of the silicified propylitic andesite seamed with reticulated quartz veinlets, which forms the hanging-wall rock of the "Big Reef."

The only available information regarding the character of this vein in the deeper mine-workings was afforded by the No. 7 level of the Royal Oak, which is 930 ft. below the outcrop of the "Big Reef" on Tokatea Hill and 647 ft. above sea-level. Examination of the vein, which at this point intersects black drossy argillites, was precluded by collapse of the adit level. It is, however, stated on reliable authority that it is here represented by a fissure containing much "mullock" and clayey material and very little quartz, the latter carrying no gold-silver values.

(b.) Veins of Tokatea Hill and Vicinity.

The veins of the Tokatea Hill and the immediate vicinity differ from those of the Success group further southward, and also from those of the Hauraki and Kapanga special areas to the westward, in that they are associated with the strata of the Tokatea Hill Series rather than with the Tertiary volcanics. The felsitic tuffs and tufaceous mudstones, which are interstratified with the ordinary grauwackes and argillites of this series, constitute the country rock connected with the more productive portion of the veins. The principal veins are here described in connection with the mining claims in which they are located. The claims at present in existence are—the Royal Oak and Tokatea, the properties of the Royal Oak Gold-mining Company (Limited); the Harbour View and Pride of Tokatea (old Hauraki Associated), the properties of the Harbour View Gold-mining Company (Limited); the New Tokatea, held by a company of the same name; the Queen of the North (Monte Cristo) and other areas held by private individuals. The areas of these claims and their relative positions are indicated on Map, page 108.

A rather significant fact, and one which has been noted by previous writers, is that the area at Tokatea, from which nearly all the gold has been won, lies between the Tokatea "Big Reef" and the rhyolite dyke existing some 20 chains to the eastward. Both the "Reef" and dyke trend approximately north-and-south and dip to the westward. This area appears furthermore to be limited to the northward by one of the bands of rhyolite which appears interstratified with the Tokatea Hill Series in the gorge of the Harataunga, and strikes in the direction of the Queen of the North Claim near the crest of the range.

Royal Oak and Tokatea Claims.—The Royal Oak and Tokatea Claims together include within their boundaries the actual summit and a portion of the eastern and western flanks of Tokatea Hill (1,577 ft.). They are the claims which have yielded the greater bulk of the gold of the Tokatea area. The

following figures, as the value of the gold and silver obtained, are much more likely to be under than over the actual amount :—

		£
From Tokatea Claim—		
By Tokatea Gold-mining Company (Auckland), September, 1869–1885		150,286
,, Tokatea Gold-mining Company and others, 1886–97		9,588
From Royal Oak Claim—		
By Royal Oak Gold-mining Company (Auckland), September, 1871–1885		22,903
By Royal Oak Goldmining Company (Auckland) ,, Royal Oak of Hauraki (London) .. ,, Royal Oak Gold-mines (Auckland) .. And others	1886–1906 ..	95,903
		278,680

Dividends reported as paid—	
By Tokatea Gold-mining Company (Auckland), totalled	63,625
,, Royal Oak Gold-mining Company (Auckland) to 1885 totalled ..	6,210
,, Royal Oak of Hauraki (Limited), totalled	12,500
	82,335

Access to the mine-workings is afforded by adit levels entcring from thc casterly slopes of the hill. There are seven of these main adits, the lowest (No. 7) being 930 ft. below the crest of Tokatea Hill and 647 ft. above sea-level. From the floor of this level, at a point about 1,850 ft. from the entrance and vertically below the crest of the range, a shaft has been sunk to a depth of 160 ft., and from this shaft a limited amount of driving and stoping has been done. Notwithstanding that the mine has been exploited from adit levels, operations have proved costly, more especially in the lower levels, on account of the hardness of the rock enclosing the veins. Rock-drills driven by compressed air have in more recent years been employed in the mine-development. The air-compressors transmitting power to the drills and also to the battery were located at the eastern base of the range, and were driven by water-power derived from certain branches of the Harataunga Stream. The rather meagre and varying water-supply and the high cost of general working-expenses has led to the abandonment of the scheme and the removal of the machinery. The company's battery comprises twelve stamps and eight berdans, the power, since the removal of the air-compressor plant, being supplied by an oil-engine.

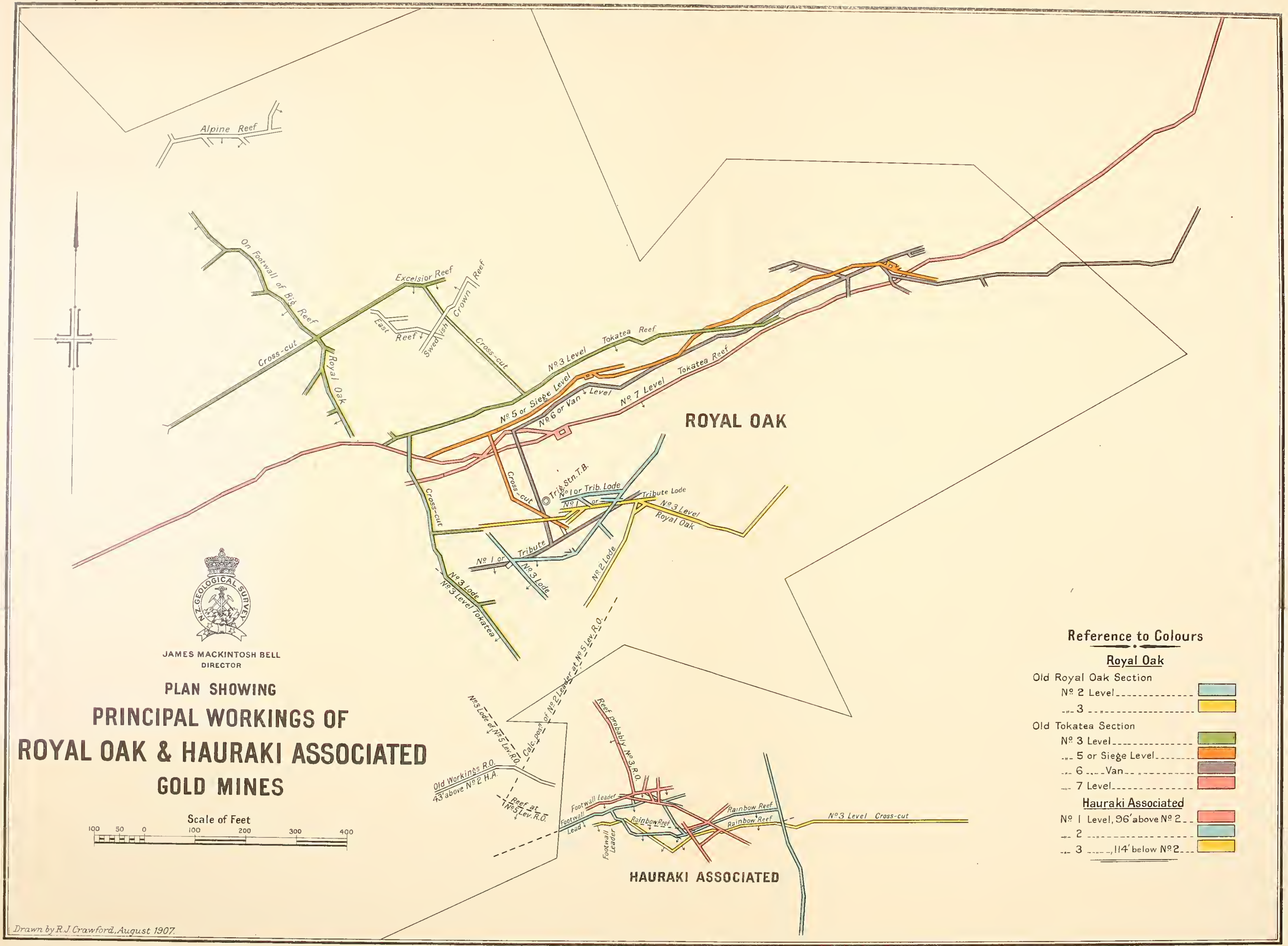
The principal veins of the Royal Oak and Tokatea Claims are the "Tokatea," "No. 1" or "Tribute," "No. 2," "No. 3," "Swedish Crown," "Alpine," and "Excelsior." All of these occur on the foot-wall side of the "Big Reef."

The "Tokatea" and "Tribute," which have proved by far the most productive of the veins named, strike respectively east-north-east and east from the "Big Reef," the "Tribute" occurring about 240 ft. to the southward of the "Tokatea," and, like it, dipping at high angles to the southward.

Quartz, calcite, and pyrite form the principal gangue-minerals, but the hydrous oxides of manganese are in places not uncommon. The calcite exists in much greater quantity than in the veins of the Hauraki and Kapanga Mines, a fact which is doubtless due to the different nature of the country rock. The gold occurs with silver in the average proportion of 100 to 50 by weight ; the latter metal is therefore more abundant here than in most of the veins connected with andesites.

The bonanza ore has been found to occur as definite shoots and irregular patches. In the upper levels of the mines the ore-shoots are said to have been intimately associated with what are termed "mineral heads" or "bars." These are apparently layers of the sedimentary rock, which originally proved more permeable to the circulating ground-waters than the general mass of the rock, and supplied aqueous precipitants of gold and silver to the vein-channels. These "mineral heads" now carry a

To accompany Bulletin No. 4



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high percentage of pyrite, cherty silica, and a clayey material, and often present a greenish coloration which may be due to sulphate or silicate of iron. In the lower levels the patches of highly auriferous ore generally occurred at the intersections of "flinties" with the veins, or occasionally in connection with faults of slight displacement. Vugs or cavities occurring within the actual veins, and often associated with bonanza ores, are not an uncommon feature in these mines. A specimen from one of these cavities shows (*a*) the wall-rock, a light-grey felsitic tuff or tufaceous mudstone, seamed with veinlets of bright pyrite; (*b*) white crystalline quartz—this contains a considerable amount of gold in a very fine state of division, and is deposited directly on the wall-rock without any intervening selvage or parting ("frozen on," to use the expressive phrase of the miner); (*c*) an irregular band of crystallized quartz showing no gold—each of the transversely set quartz prisms is terminated by pyramidal faces; (*d*) calcite containing no gold—this is deposited as large rhombohedral crystals on the comby quartz.

The order of mineral-deposition in this specimen is evident, as is also the effect of the wall-rock in the precipitation of the gold. Other specimens, however, do not show this crustification, and the quartz and calcite are often irregularly associated. The gold, while in the main associated with the quartz and pyrite, is sometimes visible as grains and threads in the cleavages of the calcite crystals.

The "Tokatea," "Tribute," and the other known veins in the Royal Oak and Tokatea Claims, have been fairly well exploited above the present adit levels. The possibility, however, of highly auriferous vein-quartz still existing, even in the near vicinity of old workings, is frequently demonstrated. The discovery of bonanza ore in Farmer's vein—a "dropper" or branch of the "Tribute" occurring below No. 5 level—has contributed most of the mine's gold-output of the last few years. This branch vein was, prior to this find, considered valueless, as the result of an insufficient amount of prospecting-work. The hardness of the country rock renders its penetration very expensive, and has thus prevented more extensive prospecting crosscuts being driven on those horizons in which the known veins have proved so highly payable.

It will be observed by the plan of the mine (Map, page 122) that the workings do not extend so far eastward on the "Tribute" as on the "Tokatea" vein. In all the levels the workings on the "Tribute" terminate in this direction at the western wall of a hornblende porphyrite dyke, which crosses the vein nearly at right angles. This dyke is about 25 ft. in width, and dips to the eastward. The fact that fairly high-grade ore has been recently found to exist in the "Tribute" vein to the east of the dyke should warrant further prospecting-work in this direction.

Disappointing results have attended operations on the "Tokatea" and "Tribute" veins at the No. 7 level. The former vein has maintained its size, but those portions carrying payable ore are few and far-between; the latter has been reduced to a mere mineralised crack, and carries no ore-values. It is stated that small patches of bonanza ore were mined from the "Tokatea" vein in the shaft-workings below the No. 7 level, but the gold won was not commensurate with the heavy expenses of pumping and winding. If further exploitation of the deeper levels of this property be attempted it will probably be by means of an adit level driven from the western slopes of the range.

Harbour View and Pride of Tokatea Claims.—The Harbour View and Pride of Tokatea Claims, situated to the south of the Royal Oak Mine, have been worked on veins which are closely allied to those already described, and, like them, occur altogether on the foot-wall side of the "Big Reef."

The main returns from the Harbour View Claim were obtained during the early days of the goldfield, and are not available. From the Pride of Tokatea, the Hauraki Associated Company and the former owners of the ground obtained, according to the statistics, during the period 1890–1900, gold and silver to the value of £11,118. The veins worked by the company were the "Rainbow Reef" and the "Foot-wall Leader," their characteristics and the enclosing rocks differing in no respect from those of the Royal Oak Mine.

West Tokatea Claim.—In the West Tokatea Claim work was confined to certain small veins occurring immediately to the south of the Tokatea Saddle, and on the foot-wall side of the "Big Reef." The rock carrying the veins is identical with certain varieties of that occurring in the Royal Oak, and porphyrite intrusions have been located. From the veins, pockets of bonanza ore have been obtained, but these were of small extent and of infrequent occurrence.

The company's battery consists of one rock-breaker, three light stamps, and two berdans.

Queen of the North (Monte Cristo) Claim.—The Queen of the North Claim is located near the crest of the range and to the north of the Royal Oak Mine. A gold-return of £1,999 is reported from the claim for the period 1887–1900. A much more extensive shoot of ore was mined in former years from the intersection of a rather large mineralised stratum (" mineral head ") with one of the veins. This " mineral head " is reported to be identical with one of the same " indicator bands " described as occurring in the Royal Oak Mine.

(c.) *The Veins of the Success Hill and Vicinity.*

Those veins of the Success Hill and vicinity which have proved of any commercial importance are, like those of the Tokatea Hill, situated on the foot-wall side of the " Big Reef." Patches of phenomenally rich ore have been obtained at different times from the various veins, but these deposits were of such small extent and infrequent occurrence that the claims have never yielded substantial returns to any of the prospecting companies. The gross returns obtained by the several companies—Success (Try Again), Southern Star, New Hauraki, and Karaka—that were operating in this special area during the years 1891–1901 only amounted, according to statistics, to £4,862.

The principal veins are termed the " Jubilee " Nos. 1 and 2, " Success " Nos. 1 and 2, and James's " East and West Reef." The enclosing rock is a propylitised andesite, apparently of tufaceous nature. According to various reports certain of these veins in the upper levels of the Success Mine afforded some splendid examples of secondary enrichment. Sheets of " gold " (electrum) without any admixture of gangue-minerals were found enclosed in open cavities in the vein fissure. These were described to the writers " as hanging from the top of the cavity like leaves of a book," an occurrence which would indicate precipitation from descending solutions.

WAIKOROMIKO SPECIAL AREA.

The Waikoromiko special area is situated on the eastern side of the main range, and between the Waikoromiko and Kopurukaitai Streams. The principal claims are located in the bold spur which separates the valleys of the streams mentioned. These claims are styled the Four-in-Hand and the Tandem.

The country rock consists of more or less propylitised andesites disposed with a dip to the eastward. The main gold-bearing rock appears to be an altered hypersthene andesite, which is observed in the lowest level of the Four-in-Hand Mine to overlie the coarsely textured hornblende andesite exposed in the bed of the Waikoromiko Creek.

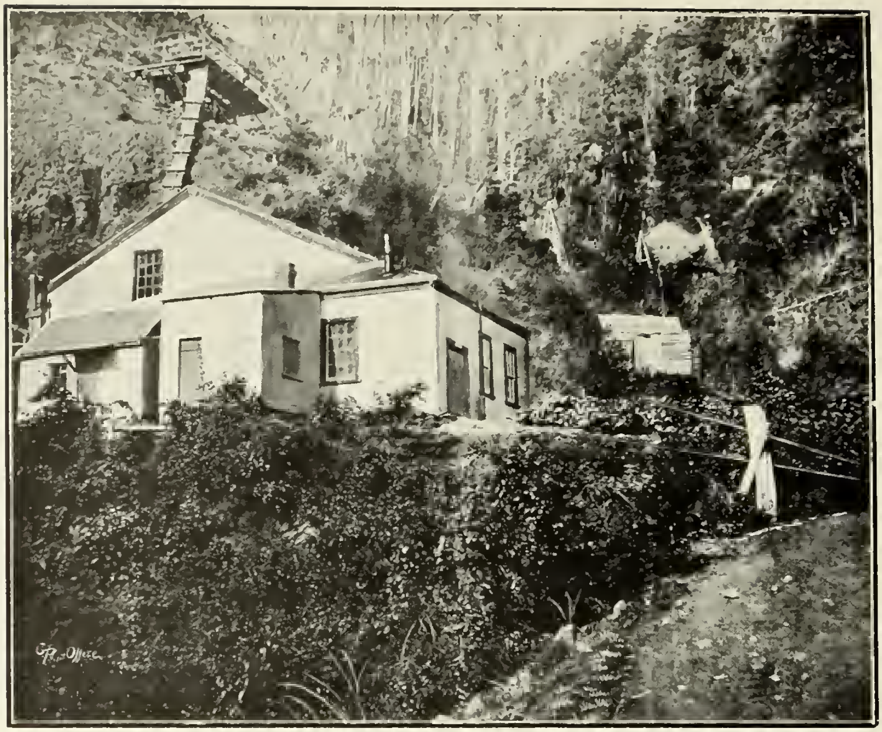
The Four-in-Hand and Tandem Mining Claims.—The Four-in-Hand Mining Claim, now the property of private individuals, was until recently worked by an Auckland company, and has from the period 1898 to 1906 obtained gold and silver to the value of £19,054. From this production dividends to the amount of £4,500 were paid.

The property has been exploited from four main adits driven from the Kopurukaitai side of the spur. A low-level crosscut driven from the Waikoromiko side was abandoned after some 875 ft. of driving had been accomplished. A further 180 ft. of driving is required to intersect the principal vein at its calculated position.

The most important vein of the claim is the Four-in-Hand, and with it are associated a foot-wall and hanging-wall branch. Other veins, among them the Tainui, traverse the property, but have received little attention. The whole vein-system has a general north-south strike, therein coinciding approximately with the trend of the main spur. The prevailing dip is to the westerly.

The Four-in-Hand vein where exploited ranged in thickness from a few inches up to 4 ft., the gold occurring in the quartz-pyrite gangue either as shoots or as a rather more general dissemination than is usual in the Coromandel veins. The much smaller hanging-wall branch afforded a considerable amount of rich bonanza ore, and where coming in contact, in its serpentine course, with the parent vein gave rise to a marked enrichment of the larger mass of vein-material. This in conjunction with other

PLATE XXXI.



NEW FOUR-IN-HAND COMPANY'S BATTERY, WAIKOROMIKO.

ROYAL OAK BATTERY; TOKATEA HILL.

[*Photo. by W. Beattie and Co., Auckland.*

facts would suggest rock-fracture and mineralisation at two different periods, the formation of the younger vein being coeval with enrichment of the older.

The Tandem Claim, held by private individuals, is located on the strike of the Four-in-Hand vein-system, but the state of the workings did not permit of its examination.

It would appear. from surface indications and from the general character of the rock forming the main spur, that further discoveries in the Waikoromiko special area may be anticipated on the trend of the vein-system both to the north and south of the Four-in-Hand Mine. Even in the existing claims the present state of mining activity appears to be largely attributable to the fact that no provision was made for prospecting-crosscuts at a time when the ore-shoots located were affording substantial returns.

The valley of the small headwater branch of the Kopurukaitai marked *d* on the general map, should warrant prospecting in view of the detrital gold in this stream-débris. Two small veins occurring at the head of this stream gave gold by crushing and panning, although the assay-result of samples taken were disappointing. The small vein exposed in the large slip at the head of this stream yielded :—

	Per Ton. Dwt. gr.
Gold	0 21
Silver	0 12

The vein some 10 chains lower down stream and on its left bank assayed :—

	Dwt. gr.
Gold	2 5
Silver	0 23

Value, 9s. per ton.

THE OLD WHANGAPOUA MINING CLAIM (LILLIS).

This claim is situated on the upper eastern slopes of the Success portion of the main range within the Waikoromiko Valley, and is apparently on the auriferous belt extending from Preece's Point to the Four-in-Hand Mine (Kopurukaitai).

This claim, worked under the above titles, has produced during the period 1890 to 1904 gold to the value of £6,450. The principal vein ranges from 2 in. to 2 ft. 6 in. in width, and is associated with propylitic andesites. The payable ore occurred in the upper levels as rich "pockets." Some of the gold obtained years ago resembled a loosely compressed mass of thread-like metal turnings. The amount obtained on one occasion would fill a couple of ore-bags, and was melted without any preparatory battery treatment. This form of gold was evidently mined from close to the surface, as a small amount of dark-brown loam was entangled with the filaments. The precipitation of gold from aqueous solutions by organic matter may probably account for this peculiar deposit.

PREECE'S POINT SPECIAL AREA.

Preece's Point is the small but conspicuous peninsular ridge jutting out from the central portion of the eastern shore-line of the Coromandel Harbour. The maximum elevation of this bare or lightly wooded ridge is about 350 ft.

The country rock consists of the volcanics of the "First Period"—andesitic tuffs, and to lesser extent lava-flows mostly in a state of advanced propylitic alteration.

Several veins, as Map (page 104) will indicate, have been located in this area. These veins vary up to a foot in width, have a general north-and-south strike, and would appear to be genetically related to those of the Hauraki special area, situated about a mile to the northward. The results that have attended the limited amount of prospecting-work have proved unremunerative, although small prospects of wonderfully rich ore have at times been encountered.

Certain veins outcropping below high-water mark on the northern shore of the area have been shown to carry ore of somewhat low grade, in which the gold appears to be more evenly disseminated than is usual in the Coromandel veins. The heavy expense for drainage caused the insufficiently capitalised syndicates or companies to prematurely abandon the prospecting operations undertaken from shafts sunk on these veins.

A general sample for assay taken from " Bremner's reef " yielded on assay :—

	Per Ton. Dwt.	gr.
Gold	3	3
Silver	1	14

Value, 12s. 8d. per ton.

THE " PROSPECTS " OF LITTLE PAUL'S CREEK VALLEY.

Perhaps no creek in the Coromandel subdivision is better known to the mining prospector than Little Paul's Creek, the main southerly branch of the Whaiwango, flowing into Koputauaki Bay. In the early days of the goldfield considerable quantities of highly auriferous vein-quartz were discovered in the débris of this stream. A great amount of prospecting has been carried out, but no vein carrying ore which is considered to correspond with these valuable erratics has ever been discovered.

Owing to the existence of an inlier of much indurated strata of the Tokatea Hill Series, at and near the junction of Little Paul's Creek with the Whaiwango, the stream has, in the soft propylitic andesites above this point, reached a false base-level of erosion. Alluvial terraces and gravel débris conceal much of the bed-rock of the valley, hence prospecting operations are rendered both difficult and expensive. Little or no detrital gold is now being delivered to the creek, so it would appear that the caps of the auriferous veins are not at the present time exposed to weathering action, but are covered by surface débris. Carbonaceous bands occur in the andesitic tuffs in the vicinity where the Coromandel – Cabbage Bay Road crosses the creek-valley. These are highly pyritised and silicified, and should, as in the Kapanga Mine, have a favourable influence on the value of any veins found to intersect them.

Between this road and the crest of the range is situated the Triumph mining area (old " Three Brothers "), the veins of which have yielded several patches of highly auriferous quartz. This quartz, it is stated, was not of the same character as the detrital ore of the lower part of Paul's Creek. An examination of both Little Paul's Creek and the Triumph area shows that there is still ample scope here for further prospecting.

THE VEINS AND MINERALISED RHYOLITES OF AITKEN, PETOTE, AND TIKI CREEKS.

The Veins.—In Aitken and Petote Creeks, branches of the Karaka, and in Tiki Creek, a branch of the Waiau River, certain veins occur at or near the contact of the andesites and the basement sedimentaries. These veins are characterized by containing in general a greater percentage of mixed metallic sulphides than those associated with the andesites ; furthermore, they have never been found to carry gold in payable quantities.

In Aitken Creek and the spur between this and Petote Creek a vein and branch vein, varying from a few inches to 2 ft. in width, have been worked by the Aitken's Freehold and Empress Companies, but without success. In Petote Creek the vein which has received most attention is known as the " Galena Lode," and occurs in the indurated argillites just below the high falls (145 ft.) in the watercourse. From what could be observed in the old workings, the vein, which ranges in width from almost zero to 12 in., has a course of north 12° west, with a dip to the westward at high angles. The vein-material is disposed as lenses, which give out along the strike (and probably dip) and are succeeded by similar lenses. These sheets consist either of quartz containing a fairly high percentage of galena, blende, pyrite, and chalcopyrite, or of quartz containing only a very sparse dissemination of these sul-

phides. The galena is argentiferous to a small extent, but gold is absent or present only in very small quantity.

Concerning this vein, Maclaren, who examined it when prospecting operations were in progress, remarks, " On assaying a bulk sample I obtained the following ore-content :—

Metal.	Quantity per Ton. Oz. dwt.
Silver	2 14
Gold	0 1
Lead	16·8 per cent.
Copper	4 per cent.

Given a sufficient quantity of ore, and with efficient concentration, the above lode should yield a handsome profit on outlay. The quantity can, however, only be determined by prospecting-drives."*

The writers have noticed from a printed prospectus recently circulated that the gold-content of this vein is considered to be much higher than that determined by Maclaren. A sample of this sulphide ore collected from the mine " paddock " was therefore submitted to the Colonial Analyst for gold-silver assay. The report is as follows :—

	Per Ton. Oz. dwt. gr.
Gold	0 0 14
Silver	1 8 8

The prospecting operations undertaken since Maclaren's report was written have failed to show that the vein contains the ore in payable quantities ; further attempts to prospect this and other veins are, however, contemplated.

Another vein, or a further outcrop of the one already described, is exposed in an open cut some 7 chains further up the creek. The actual vein-material here measures 6 in. in width, while the wall-rock on its hanging-wall side is sparsely impregnated with sulphides for a distance of 2 ft.

Two distinct bands constitute the vein proper—one. 2 in. to 3 in. in width, consisting of rusty quartz, the other, 3 in. to 5 in. in width, of quartz high in chalcopyrite and its alteration-products.

The following is the result of an analysis of the rusty quartz :—

	Per Ton. Dwt. gr.
Gold	Nil.
Silver	7 13

An analysis of the quartz-chalcopyrite ore resulted as follows :—

	Per Ton. Oz. dwt. gr.
Gold	Nil.
Silver	1 2 16
Copper	13·78 per cent.

The vein, on account of its copper-content, warrants further prospecting at this point.

In the right branch of Tiki Creek there are indications of the existence of veins similar to those of Petote Creek. At an elevation of 300 ft. (site of old dam) and a distance of 35 chains north of the main junction, a small galena seam about 1 in. wide is seen in the argillites of the creek-bed. Seven chains further north, and on the east side of the creek, a vein striking north 23° west has been located and drifted on some distance. It varies from 2 ft. to 3 ft. in width, and consists of quartz carrying a very small percentage of pyrite, galena, and chalcopyrite. Analysis for gold and silver yielded,—

	Per Ton. Oz. dwt. gr.
Gold	0 0 15 to 0 0 18
Silver	0 4 2 to 0 18 7

* C.-9, 1900, p. 9.

Mineralised Rhyolites.—It has been stated in connection with the Pre-Jurassic stratified rocks that contemporaneous bands of rhyolite occur in association with the sedimentaries of the Tokatea Hill Series.

In the Tiki and Petote Creeks these rhyolites are highly silicified, and, as the result of the decomposition of pyrite, are impregnated with iron-oxides. As it appeared probable that gold and silver might have been introduced with these secondary minerals, general samples of the rock were taken for analysis. The results, which are as follows, indicate, unfortunately, that these rock-masses have no economic value as ores.

	Per Ton. Gold. Dwt. gr.	Per Ton. Silver. Dwt. gr.
Analysis of silicified rhyolite from—		
Tiki Creek	Nil	2 2
Petote Creek	0 14	0 8

Value of sample from Petote Creek, 2s. 4d. per ton.

VEINS OF TIKI HILL AND MATAWAI VALLEY.

The Tiki Hill and Matawai Valley have from time to time, since the early days of the goldfield, been the scene of active prospecting and mining operations. Limited patches of rich bonanza ore were obtained by the early prospectors, but the results attending the more extensive operations of the several companies were rather disappointing. During the period 1887–1906 the recorded value of the gold obtained only amounted to £3,829, and probably £20,000 would cover the total output since the opening of the field. The area is at present almost abandoned, and, owing to the collapsed state of the old workings, it is impossible to even map the positions of the veins.

In Blackmore's old claim on the Tiki Hill, between the Pukewhau and Opitonui Saddles, the veins appear to have been associated with the altered interstratified rhyolites of the Tokatea Hill Series, but probably extended into the overlying andesites. From the Mines Report of 1887 it would appear that the vein in the adit entering the hill from the level of the Coromandel–Opitonui Road (that is, in the rhyolites) was about 18 in. thick, but carried little or no payable quartz ; it is likely, therefore, that the bonanza ore occurred in the vein at the higher levels where associated with andesites.

In the Pukewhau Claim, on the upper slope of the hill overlooking Pukewhau Creek, only a limited amount of andesite overlies the sedimentary rocks, the lowest adit being driven near the contact of the two formations. In this adit the small vein, which had yielded pockets of very highly auriferous quartz in the upper levels, was unpayable.

In what is probably the old Golden Belt Claim, adits penetrate the altered grits of the Manaia Hill Series, but whether or no payable returns were obtained here could not be ascertained.

It would appear therefore that mining on the Tiki Hill has been connected with three distinct rock-formations—namely, the Tokatea Hill Series, the Manaia Hill Series, and the "First Period" andesites. It is, however, fairly safe to assert that the veins in the andesites have yielded the greater bulk of the gold.

Mention should here be made of a large quartz vein which occurs at an elevation of 730 ft. on the ridge traversed by the Tiki–Opitonui Road, and lying between the Pukewhau and Matawai Valleys. This vein is associated with argillites, and is not far distant from an intrusion of porphyrite. Its strike is probably about north-south, and its width may exceed 10 ft. or 15 ft. The finely crushed quartz, which contains a little pyrite, yields, on carefully "panning off," a small amount of gold in a finely divided state. Only a limited amount of work has been done on the vein, and further prospecting on its southerly extension in Endean's Mining Freehold, where the country falls steeply, would seem advisable.

Within the Matawai Valley the most productive veins yet discovered occur on the southern slopes, about a mile and a half from the stream's junction with the Waiau River. These veins are included within the old claim known as Vizard's and Vaughan's (Matawai). The latter claim, worked during the years 1887 to 1903 under the title of the "Castle Rock," produced gold and silver to the value of £2,770.

The country rock of the Castle Rock Claim consists of propylitic andesite, overlying an old highly inclined surface of the Manaia Hill grits and argillites. In the workings from the lowest adit the principal vein ranges from 2 in. to 1 ft. in width, and is associated with the andesites. In addition to pyrite, arsenopyrite and a small amount of stibnite occurred throughout the quartz; the ore had therefore to be calcined in order to extract the gold by the amalgamation process. A smaller branch vein was observed in the workings, occurring at the contact of the andesites and argillites, but this apparently yielded no payable ore.

In Vizard's Claim none of the workings admitted of examination, but the vein-material bears the same character as that of the Castle Rock.

All the highly auriferous quartz from these two claims was evidently mined from the upper portions of the veins, where they are associated with the andesitic rock.

"PROSPECTS" OF MANAIA VALLEY.

Within the Manaia Valley the prospecting and mining operations of the past have not been attended with remunerative results, although small patches of "specimen stone" have been occasionally unearthed. Most of this highly auriferous ore has been derived from the small veins of the Victoria or Golden Hill Claim, which lies immediately to the south of the subdivision.

As at Tiki Hill, three distinct rock-formations—Tokatea Hill Series, Manaia Hill Series, and the "First Period" andesites—are involved in the structure of the Manaia area. While gold has been found in the débris of streams incising each class of rock, payably auriferous veins have never been located.

In Taurarahi Creek the alluvium affords more gold on washing than does that of any other creek in the subdivision. Much of this gold exists as heavy particles. Since no quartz veins were detected in the course of the creek, nor do quartz fragments occur in the débris to any considerable extent, it would appear that some, if not all, of the detrital gold has been derived from joint-planes in the grits and argillites. These joints are filled with iron-oxides, and have been proved to contain more or less gold. The latter metal may have been originally introduced in a pyritic matrix, or has either gravitated or descended in solution during weathering processes from higher levels. The old Leading Wind Company would appear to have exploited "irony" seams of this nature, with results which inevitably proved unremunerative. Near the headwaters of the Taurarahi, and extending to the Mahakirau divide, a belt of propylitic andesites exists, which might be expected to afford, on prospecting, better results than the lower part of the valley.

In the two main branches of the Manaia the area mapped as Tokatea Hill Series affords the light-grey spotted tuffs and tufaceous mudstones so characteristic of the Royal Oak and other mines of the Tokatea. Quartz veins do not appear in these rocks in the exposures afforded by the creeks, nor do the rocks, although highly pyritised, show pyritic bands such as are usually associated with the highly auriferous quartz veins of Tokatea. It cannot be affirmed, however, that the Manaia Valley has been systematically prospected, and there appears to be no reason why further discoveries should not be made.

VEINS OF OPITONUI VALLEY.

The Opitonui special area is situated within the valley of the Opitonui Stream (Whangapoua). The country, which in the vicinity of the vein has little local relief, consists of more or less propylitised andesites referable to the "First Period." Associated with these volcanic rocks in the Maiden Mine, a hornblende porphyrite has been detected, thus suggesting the presence of intrusives.

Prospecting and mining operations on this particular area date from the year 1890, but the total value of the output recorded up to 1893 is only £1,025. In 1899–1903 the operations of the Kauri Freehold Gold Estates (Limited) were mainly centred in this locality (see page 16), ore to the amount of 53,355 tons being mined and milled for a gold-silver return valued at £63,723.

The principal veins worked here were designated the Maiden, Carvill, and Hilda; others of lesser importance being the Opitonui, Zealandia, Australasia, and Cross Reef. The three first-named veins show strikes not far removed from east and west, but the Opitonui—a large vein—and certain others more nearly approach the meridional direction. Only scanty information is available as regards the vein-characteristics or underground conditions. The most productive vein—the Maiden—ranged from 2 ft. to 14 ft. in width, with an average of about 6 ft. In the lowest mine-level the vein, which in the softer propylitic rock preserved the average width quoted, contracted immediately to about a foot on intersecting a "hard bar." The latter is probably the dyke which has afforded the specimen of hornblende porphyrite collected by McKay from the "tip-head." If so, the intrusions are evidently of greater antiquity than the veins.

The gold and silver, alloyed in about equal proportions, occurred fairly evenly disseminated throughout the ore and also in a state of greater concentration in certain thin partings in the vein.

The Opitonui vein, which is from 10 ft. to 12 ft. in width, outcrops conspicuously on the left-hand branch of the Opitonui Stream at a low elevation. Its northerly continuation would appear to form the quartz "blow" appearing some few chains south of Lanigan's shaft. The vein-material as exposed consists of white crystalline quartz showing partings stained with oxide of manganese. The sample taken for analysis gave negative results for gold and silver, but trial crushings taken from certain points are said to have proved the vein-material to be auriferous, though not payably so.

VEINS OF THE MAHAKIRAU VALLEY.

The valley of the Mahakirau above the junction of the Waitakatanga Creek includes two areas, which are more or less auriferous.

One of these is included within a belt of propylitic andesites, about 60 chains wide, extending from the headwaters of Battery and Waiparu Creeks on the south side of the main valley, into the watershed of the Day Dawn and other small creeks on the north side of the valley. The other belt, a mile and a half further westward, includes the watershed of Jubilee Creek and extends westward and south-westward to the main river, which here flows in a northerly direction.

Veins of Battery and Day Dawn Creeks.—In Battery Creek, at a point about 45 chains from the main river, there is exposed a quartz vein 20 ft. in width striking north 30° east. On its southerly extension it forms the conspicuous "quartz blows" on the ridge between this small creek and McIsaacs Creek. The quartz contains pyrite and a small percentage of antimonite. No gold could be detected on crushing and panning, while the sample submitted for analysis returned only—

	Per Ton. Dwt. gr.
Silver	2 13

Some work appears to have been done on this large vein, but with what results could not be ascertained. A nearly parallel vein 12 in. in width, which appears from the "dump" to have been drifted on for a long distance, is exposed at a point 4 chains further up the creek. No "prospect" could be obtained by crushing and washing the vein-material.

A third vein, showing a width of 6 ft., occurs 20 chains from the mouth of this creek. It stands above the soft decomposed andesite as a strong rib striking north–south, and is followed by the creek for some distance. Pyrite and antimonite are conspicuous in the vein-material, but concentration-tests showed no gold.

An analysis yielded—

	Per Ton. Dwt. gr.
Gold	0 7
Silver	0 22

From the "prospects" of gold contained in the débris of Battery Creek nearer its mouth, it would appear that an auriferous vein not yet located exists lower down the creek-valley than the veins just described.

To the north of the Mahakirau River a vein known as the Day Dawn has been located on the small spur lying to the west of the Day Dawn Creek. This vein, which strikes north 27° east, and dips to the north-west at an angle of 65°, ranges from 4 in. to 2 ft. 6 in. in width. The lode-matter is poorly demarcated from the wall-rock. It consists principally of quartz, oxides of iron and manganese, and yellow clayey material. Gold is occasionally visible in the ore, and it is stated that the trial crushings gave returns which would show a margin of profit provided more systematic methods of mining and crushing were adopted.

A sample of the vein-material taken from the only accessible part of the western adit yielded on analysis—

	Per Ton. Dwt.	gr.
Gold	3	10
Silver	1	14

Value, 13s. 10d. per ton.

Mention should here be made of a patch of "specimen stone" reported to have been discovered in landslip-débris on a terrace of the southern bank of the Mahakirau River, midway between the mouths of Battery and Day Dawn Creeks. The many small adits observable in the vicinity of this terrace are evidences of futile attempts to locate the parent vein. An examination of the locality would suggest that this auriferous vein-quartz had its origin at a somewhat higher elevation than that of these adits and prospecting-pits.

Veins of the Jubilee Creek and Vicinity.—In Jubilee Creek the most productive vein yet located occurs about 60 chains from the main river. (See map.) Although only 2 in. to 5 in. in width, the vein is well defined and has yielded a few small shoots of highly auriferous ore. Stratified andesitic tuff or ash-beds, highly propylitised, constitute the enclosing rock. The last return reported was obtained in the year 1901, when 6 tons of ore yielded gold-silver bullion to the value of £348.

A similar vein, upon which no work has been done, outcrops in the creek-bed about 35 chains nearer the river. A sample of the quartz gave on analysis—

	Per Ton. Dwt.	gr.
Gold	0	22
Silver	0	15

On the spur to the westward of Jubilee Creek a vein of some 2 ft. in width has been recently located. Two samples forwarded to the writers were analysed, with the following result:—

(1.)

	Per Ton. Oz.	dwt.	gr.
Gold	0	1	6
Silver	2	15	11

Value 11s. 6d. per ton.

(2.)

	Oz.	dwt.	gr.
Gold	0	0	15
Silver	1	10	21

Value, 6s. 3d. per ton for gold and silver.

Antimony was present in this ore to the extent of 9·66 per cent.

VEINS OF MATERANGI, MURPHY'S HILL, OWERA, AND MOEWAI.

A fairly well-marked line of mineralisation is that extending from Materangi Ridge, near the northern coast-line of the Kuaotunu Peninsula, through Murphy's Hill and the Owera Valley to the Moewai Claim, situated near the head of the Ngarahutunoa Creek, flowing into Mercury Bay.

The rocks of this belt are fragmental and massive andesites and dacites of the "Second Period," considerably propylitised and weathered. This weathered rock presents a rather coarse texture and a characteristic purplish-grey colour.

The veins, on account of the somewhat sintery and occasionally platy character of the quartz and the fairly uniform dissemination of the gold-silver content throughout the ore, resembled the Kuaotunu rather than the Coromandel veins. The very high-grade ore characteristic of the last-named locality has never been found in the mines located on this belt, nor have any of the mines it may be remarked, yet yielded remunerative returns to the owners.

Materangi Ridge Veins: The principal vein of the now abandoned Wild Wave and Ocean View Claims traverses nearly longitudinally the Materangi Ridge. It strikes north 10° west, dips at high angles to the westward, and ranges from a few inches to 3 ft. in width. The vein-material consists of a loose mass of quartz, silicified rock, and clayey material, stained with iron and occasionally manganese oxides, and is not sharply demarcated from the wall-rock. A general sample taken from the vein in those parts of the old workings still accessible gave on analysis—

	Per Ton. Dwt.	gr.
Gold	6	22
Silver	3	4

Value, £1 8s. per ton.

Statistics show that 34 tons of ore was crushed from the Ocean View Claim during the period 1892–93, for a return valued at £200.

Murphy's Hill Veins: At Murphy's Hill the principal vein presents similar characteristics to that of Materangi, except that sintery white quartz and the oxides of manganese are here more abundant. The vein, which is exposed both on the north-east and southerly flanks of the hill, strikes north 45° east, and dips to the south-east. Its width, from what can be observed in the old workings, appears to average about 3 ft.

A general sample of the vein-material, broken from the reef on the north-east side of the hill, yielded on analysis—

	Per Ton. Dwt.	gr.
Gold	0	7
Silver	0	23

From the old mine-workings of the southerly flank of the hill—

	Per Ton. Dwt.	gr.
Gold	1	13
Silver	0	23

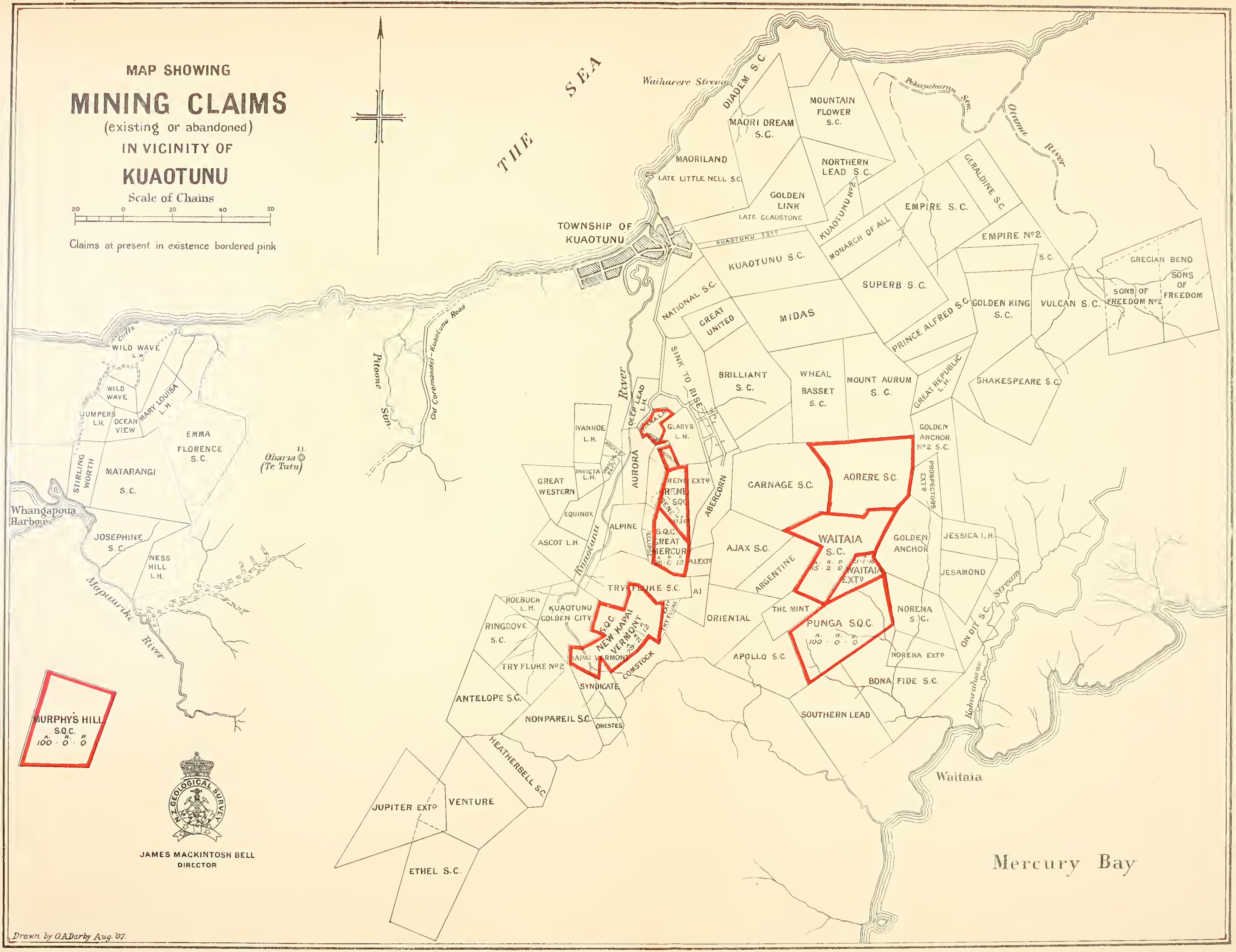
A crushing of 4 tons of ore from Murphy's Hill during the period 1891–95 yielded 48 oz. 1 dwt. of bullion, valued at £105 12s.

Owera Veins: In the Owera Claim, situated on the spur lying between branches of the Owera and Otanguru Creeks, mining operations rather more extensive than at the two localities just described have been carried out. The proprietary company erected a 10-head stamp-battery in the vicinity, and during the period 1890–95 mined and crushed 1,786 tons of ore for a return of 2,207 oz., valued at £3,806.

Collapse of the entrances to the several adits precluded examination of underground conditions. The principal vein—the Owera—has a strike of north 30° east, and a dip at high angles to the eastward, with a width averaging 2 ft. In addition to the brownish oxidized sintery quartz pitted with drusy cavities, the white friable laminated variety, characteristic of Kuaotunu, is occasionally visible.

Several outcrops of vein-material have recently been located by prospectors on the Otanguru slope of the spur. General samples from these occurrences showed on analysis a gold-content varying from 22 gr. to 1 oz. 16 dwt. per ton, and silver 1 dwt. 22 gr. to 2 oz. 3 dwt. 12 gr. per ton. Since the exposures are in the near vicinity of, and at a higher elevation than, the deepest of the old workings, they may only be the outcropping portions of the Owera vein, already worked. A reopening of the old adits can alone prove their commercial value.

The Moewai Claim: The principal vein of the Moewai Claim—Ngarahutunoa Valley—closely resembles in the character of its ore the Owera and Materangi veins. Its course is north 20° east, dip is to the eastward at high angles, and width averages from 3 ft. to 4 ft. The ore is of low grade, although



By Authority: John Mackay, Government Printer, Wellington.

gold is occasionally visible in the solid quartz or in association with the iron-oxides. The steepness of the country gives facilities for cheap mining. The proprietors of the claim, being of opinion that the ore of the upper levels will leave a margin of profit, have a small stamper-battery in course of erection.

VEINS AND MINING CLAIMS OF THE KUAOTUNU SPECIAL AREA.

Locality and General Features.

The Kuaotunu special area includes the watershed of the Kuaotunu Stream, and has further extension to the eastern slopes of the Waitaia Ridge, and to the southern slopes of the hilly country overlooking Mercury Bay. With the exception of the floor of the middle and lower parts of the river-valley the area is decidedly hilly, and in the south-eastern portion steep and rugged. The bold north-south-trending Waitaia Ridge, terminating near the northern coast-line in Black Jack Hill, forms the eastern part of the area. About a mile to the westward, and nearly parallel to this ridge, the Bald Spur is a conspicuous feature, jutting northward from the Kuaotunu Range and terminating in the valley between the two main branches of the Kuaotunu Stream.

Geological Formation

As the general map will show, the prevailing rocks of the area are those of the Manaia Hill Series (Jurassic). They consist here of fine conglomerates, gritty grauwackes, and argillites, considerably altered in the vicinity of the veins by hydrothermal agencies. In the small creek west of Hosie's Saddle, and within the boundaries of the Waitaia Mining Claim, there is exposed a small patch of spotted tufaceous mudstones, which has been referred to the Tokatea Hill Series. This rock is identical with much of that occurring in the Royal Oak Mine (Tokatea). The Kuaotunu area of sedimentary rocks is on three sides flanked and overlain by the andesites of the Beeson's Island Series. Special mention should here be made of a small tongue of andesite which, extending northward from the main mass of the volcanics, forms the capping of the Bald Spur within the Kapai-Vermont Mining Claim.

In connection with rock-alteration, reference has been made (see page 101) to the marked resemblance which the altered grits of the Kuaotunu area bear to propylitic andesites. On this account the contact of the andesites and the sedimentaries, in the mine-workings of the Kapai-Vermont Claim, was evidently not recognised by those connected with the mining operations.

The Veins and Mining Claims.

Two principal areas of mineralisation are recognisable on the Kuaotunu Goldfield—(*a*) that of the Bald Spur, enclosing the "Try Fluke" and allied veins; (*b*) that of the Waitaia Ridge, enclosing the veins of the Waitaia and other claims.

With the exception of the minor capping of andesite on the south end of the Bald Spur, the rocks enclosing the veins are the gritty grauwackes or argillites. In no other part of the subdivision have payably auriferous veins been shown to exist in the rocks of the Manaia Hill Series. Furthermore, it will be noted from the following description that the character both of the gangue-minerals and the gold-silver content distinguishes the veins of Kuaotunu from those of the main Coromandel centre.

The total gold-silver returns of the Kuaotunu Goldfield, from its discovery (1889) to the 31st December, 1906, according to the official reports amount to 82,756 oz., valued at £190,795, the amount of ore treated being 95,865 long tons.

Veins of the Bald Spur and Vicinity.

The principal vein of the Bald Spur, and the one which yielded the greater part of the gold of the Kuaotunu area, is known as the "Try Fluke." Its course is north 22° east, and its dip is south-east at high angles. Professor Park, who examined the vein while mining operations were in progress, says: "It varies from 2 ft. to 12 ft. in width, and generally consists of friable crystalline quartz, often stained a black colour by manganese-oxides. In the more solid parts the lode-matter consists of flaky masses of quartz, made up of numerous thin leaves or laminæ of quartz often enclosing hollow rhombohedrons or triangles, which appear to be pseudomorphs after calcite. The laminæ are often as thin as a knife-blade, and, although closely packed like the

leaves of a book, do not touch each other, being separated by a space the thickness of a sheet of paper. They appear to have formed along the cleavage-planes of calcite crystals."* Probably owing either to a crush effected by later movements of the wall-rock, or to a subsequent leaching-out of calcite deposited in intimate association with the quartz, much of the vein-material in the Try Fluke Mine is stated to have resembled "a mass of gritty sand." The tendency of this material to "run" necessitated special precautions being taken in stoping operations.

Every mining report on Kuaotunu makes reference to the exceedingly fine state of division in which the gold-silver electrum existed in the ore, and particularly in the ore of the Try Fluke vein. The percentage recovery of this fine gold by the ordinary amalgamation process as practised at Coromandel proved altogether unsatisfactory, and not until the introduction of a leaching process (cyanide) was the metallurgical problem afforded by these ores solved. The payably auriferous ore in the vein was disposed as a shoot of considerable width, pitching at a low angle to the southward. The richest portion in this shoot was at or near the vein's outcrop on the top of the spur (elevation, 650 ft.). Much of this gossanous ore, evidently the result of repeated natural concentrations, yielded over 15 oz. of gold per ton. Below this, in the Try Fluke Claim, ore of payable quality continued for some depth below the No. 4 level (270 ft. elevation). From this level, at a point 200 ft. north of where the Try Fluke vein crosses the Kapai-Vermont Claim boundary, a shaft was sunk to a depth of 100 ft. In the lower 10 ft. of this shaft a decided "change of country" is stated to have been encountered, with a pronounced impoverishment and contraction in width of the vein. Below this break the rock is stated to be dark-coloured and soft, but in the opinion of the mine-manager† operations were prematurely abandoned owing to lack of capital.

In the low level of the Great Mercury Mine, some 45 chains northward of the Try Fluke shaft, the vein has been intersected at an elevation of some 135 ft. above sea-level (that is, at an horizon 40 ft. lower than the workings from the Try Fluke shaft). Here again the vein, which intersects hard gritty grauwacke and argillite showing only a minor amount of alteration, is of small dimensions, and carries gold and silver to the extent of only a few grains per ton. In the upper levels of the Great Mercury the vein averaged 4 ft. to 5 ft. in width, afforded much high-grade ore, and was enclosed in a more highly altered phase of the same rock.

To the east or hanging-wall side of the "Try Fluke Reef" occur veins known as the "Kuaotunu," "Red Mercury," and "Just-in-Time," all of which have yielded a considerable amount of payably auriferous ore. Other veins of the Bald Spur are those of the Otama and Handsworth Claims, which though small have afforded rich ore-shoots.

The following tabulation, compiled from official reports, shows the results of mining operations on the several claims held from time to time on the Bald Spur :—

Mine.	Period of Operation.	Quartz crushed.			Bullion obtained.		Value		
		Tons	cwt	lb.	Oz.	dwt.	£	s.	d.
Kapai	1891–92	120	0	0	103	0	234	6	6
Kapai-Vermont	1893–98	10,209	0	0	12,679	5	29,028	18	2
Try Fluke	1890–97	35,565	0	0	24,620	5	58,762	19	8
John Bull	1891–92	105	0	0	20	2	45	4	6
Just-in-Time	1890–95	991	0	0	1,009	13	2,275	19	9
Carbine	1889–92	428	0	0	956	10	2,152	2	6
Mariposa	1891–93	680	0	0	416	4	937	9	0
Red Mercury	1890–95	4,556	0	0	5,485	16	11,893	1	0
Kuaotunu Syndicate‡	1901–2	2,215	0	0	1,061	15	2,356	8	2
New Mariposa§	1897–1903	8,979	0	0	4,273	6	9,679	7	8
A 1	1896–97	28	0	0	6	0	14	0	0
Great Mercury	1889–1903	20,373	5	0	14,502	16	29,755	15	1
Irene	1891–1902	3,087	0	0	2,642	9	5,025	2	4
Handsworth	1896–1906	393	11	48	1,448	11	3,645	1	3
Otama	1889–1906	310	9	40	1,431	0	3,255	0	6
Juno	1896–1902	74	2	108	708	4	1,647	7	0
Totals		88,114	8	84	71,364	16	160,7[illegible]8	3	1

* "Geology and Veins of the Hauraki Goldfields," 1897, p. 100. † The late Mr John Goldsworthy. ‡ Kuaotunu Syndicate claims are Mariposa and Kapai-Vermont. § New Mariposa included the Try Fluke, with its different sections, and the Kapai-Vermont.

Invicta Claim: The Invicta Mining Claim is distant some 30 chains from the Bald Spur, and is on the west side of the Kuaotunu Creek. The vein, which was worked in this claim at an elevation of about 120 ft. above sea-level, is about 4 in. wide. Its course is north 10° west, and its dip 60° to the westward. The workings have collapsed. A sample of the oxidized vein-material taken from the "paddock" yielded on analysis,—

	Per Ton. Oz. dwt. gr.
Gold	0 13 20
Silver	2 2 20

Value, £2 19s. 7d. per ton.

During the period that mining operations were in progress 575 tons of ore were raised and treated, for a return of gold valued at £493.

The Veins and Siliceous Sinters of the Waitaia Ridge.

The Veins.—The principal veins of the Waitaia Ridge outcrop on its western slope about 36 chains to the south-west of Trigonometrical Station H. These are the ore-bodies of the Waitaia Mine. Minor veins also occur both to the north and south of this locality.

Waitaia Mining Claim: The Waitaia Mining Claim, the property of the Waitaia Gold-mining Company, covers some 107 acres of the steep western slope of the ridge. The rocks consist entirely of altered sedimentaries, the disposition of which is not recognisable. Some half a mile to the north-east, however, the strata exhibit a north-south strike, with a dip to the westward.

The principal vein is the Waitaia No. 3, while the No. 5, with its branch the "Blue Face," ranks next in importance. The No. 3 vein has a rather serpentine course averaging north 20° east. Its dip is irregular, varying from 72° to the eastward in the northern portion of the claim to 75° westward in the southern portion. All positions between those mentioned are encountered in this "warped" fissure. The vein, which is rather lenticular, ranges up to 10 ft. in width, and averages from 12 in. to 15 in. It is the result both of fissure-filling and of replacement of the wall-rock. Where best defined the vein-material consists mainly of white crystalline quartz, with bands or patches of dark bluish-grey quartz. Pyrite is abundant, particularly in darker bands and as thin films separating the darker- and lighter-coloured quartz. Arsenopyrite, galena, and blende are occasionally present in minor quantity. The gold, which occurs with silver in the average ratio of 100 : 39, is usually associated with the granular pyrite and pyritic films. What is locally termed "conglomerate" occurs comparatively frequently as the only vein-filling, and is of very low grade or non-auriferous. This is evidently a fissure-breccia — angular and rounded fragments of wall-rock cemented with a minor amount of siliceous material. The disposition of these breccia occurrences as "shoots" pitching at high angles, denotes vertical movement in a sinuous fault-fissure.

The shoot of pay-ore in this vein has been followed to a depth of some 300 ft. below the outcrop. Including a few minor belts of non-payable "conglomeratic" and barren ore, the pay-shoot, which pitches southward at 45°, has a stope-length of 1,000 ft. Pockets of "specimen stone," ranging in gold-content up to "3 oz. to the pound," are of occasional occurrence. A fault which effects a horizontal displacement of the vein of some 16 ft., in the northern end of the mine-workings, dips at high angles to the southward, and appears to limit the ore-shoot in this direction.

The No. 5 vein, distant 130 ft. to the eastward, is nearly parallel in strike to the No. 3, and dips at high angles to the eastward. It has been intersected and drifted upon in the upper levels, showing an average width of 15 in. The rusty-coloured oxidized ore yielded battery-returns at the rate of £1 per long ton.

The company's mill, which is situated some 75 chains from the mine, consists of ten stamps, together with a poorly arranged cyanide plant and accessories, the motive power being steam.

According to official statistics the Waitaia Gold-mining Company treated, during the period 1891–1906, 5,848 tons of ore for a gold-silver return valued at £26,404.

A low-level adit has been surveyed, which will intersect the veins at a depth of 160 ft. below the No. 5 level. The country rock exposed in the small creek rising in Hosie's Saddle, and at an elevation

of some 40 ft. above the proposed adit, closely resembles, as already stated, the rock of the Royal Oak Mine, Tokatea. The phase of alteration exhibited by this rock, which will probably be penetrated in the low level, together with the results afforded by the vein at No. 5 level, are sufficient warranty for the contemplated expenditure in further development.

Aorere Claim: In the Aorere Claim, lying immediately to the north of the Waitaia property, a continuation of what is probably the Waitaia No. 3 vein has been located. From the year 1893 to 1899, 295 tons of ore were crushed for a return of £1,028. This was, it is said, mostly derived from a "chimney-like" ore-shoot of lenticular cross-section.

Golden Anchor Claim: In the Golden Anchor Claim, to the east of the Waitaia, a vein 3 in. to 7 in. in width has been drifted on for some distance. A general sample selected yielded on assay only—

	Per Ton. Oz.	dwt.	gr.
Gold	0	0	15
Silver	0	0	15

New Mint Claim: In the New Mint Claim, to the south of the Waitaia Mine and on the slope of the range overlooking Mercury Bay, a vein about 15 in. thick has been exposed. Its strike is north 35° east, dip 65° westward, and width 15 in. This vein is evidently allied to the Waitaia veins, but the gold-content of the portion exposed is small. Analysis showed—

	Per Ton. Oz.	dwt.	gr.
Gold	0	1	6
Silver	0	1	6

Other Claims: The following returns from various other Kuaotunu claims are submitted, to complete the recorded gold-silver returns from the field up to the end of the year 1906:—

Mine.	Period of Operation.	Quartz crushed. Tons.	cwt.	Bullion obtained. Oz.	dwt.	Value. £	s.	d.
Black Jack	1891–94	215	10	313	1	752	6	5
Bonanza	1890–91	10	0	19	6	55	19	8
Excelsior	1892–93	74	0	31	0	77	10	0
Kuaotunu	1891–94	507	0	310	5	653	1	3
Secret	1890–91	4	0	4	6	9	0	0
Venus	1895–96	96	0	153	1	382	15	0
Try Again	1894–95	13	0	11	12	26	2	8
Three Stars	1894–95	12	0	6	2	14	11	5
Loyalty	1893–94	7	0	8	5	20	0	0
Perseverance	1893–94	31	0	41	11	97	12	6
Victoria	1893–95	41	0	12	10	29	7	6
Lucky Hit	1893–95	22	0	18	17	44	6	0
Totals		1,032	10	929	16	2,162	12	5

The Siliceous Sinters.—One of the most conspicuous features on the crest and flanks of the Waitaia Ridge are the white terraces and "shoadings" of siliceous sinter, the products of hot springs that formerly existed along its whole length. The most characteristic terrace formation occurs on the crest of the ridge at a point 50 chains south-east of Black Jack Hill, the accumulation being disposed as nearly horizontal layers. (See Plate 32.) The material, which is white or slaty-coloured, and often vitreous, is in places of flinty nature, or again is finely crystalline. Layers showing porous or fibrous structure and stained with iron and manganese oxides are not uncommon. Four general samples were collected from various parts of these superficial deposits of sinter, but on analysis showed no traces of gold or silver. During the period of mining activity, adits were extended from the range-slopes under certain of these sinter cappings, in the hope that they might be connected with ore-bearing fissure-veins, but no veins of any description were encountered.

Black Jack Hill, at the northern end of Waitaia Ridge, appears to have been the pipe of one of these old thermal springs. The sintery quartz and silicified grauwackes here contain a much higher

PLATE XXXII.

Siliceous Sinter Terrace on Waitaia Ridge, Kuaotunu.

Siliceous Sinter Terrace on Waitaia Ridge, Kuaotunu.

[Photo. by Mr. Alex. McKay, F.G.S.

percentage of iron and manganese oxides than do the superficial terrace deposits. A complete sampling of this material was undertaken at all points of exposure, and ten assay samples prepared :—

	Gold. Gr.	Silver. Gr.
2 samples yielded on analysis	3	5
4 samples "	3	12
1 sample "	7	8
1 sample "	11	4
1 sample "	1	14
1 sample "	Nil.	Nil.

The above results, though of scientific interest, show that the deposit has no economic value as a gold-silver ore.

VEINS OF WHAUWHAU CREEK.

The Whauwhau Creek, draining into Mercury Bay, incises the hilly country some two miles due south of the Kuaotunu Bald Spur. The rock consists altogether of "Second Period" andesites, propylitised and weathered. The locality is apparently on the southerly extension of the Kuaotunu general line of mineralisation. Intermediate between Whauwhau and Kuaotunu, highly pyritised propylitic andesites are found in the middle and upper course of Woodcock Creek.

The only vein observed in these prospecting adits at the Whauwhau (see general map) strikes north-south, and ranges in size from a mere clay parting to a quartz-clay formation about a foot wide. The solid quartz, which resembles that of the Owera veins, contains very little gold. This metal exists only in the loose rusty clayey material, and as films on the walls of cavities in the quartz. Such vein-material is always of lower grade than it appears to be, and mining at Whauwhau has proved unremunerative.

PURANGI SPECIAL AREA.

The Purangi rhyolitic area—that lying to the east of the Whitianga Harbour—is markedly devoid of quartz veins. A fissure, or "pipe" deposit, of vitreous, cherty, siliceous sinter, of considerable dimensions, occurs in the valley of the small creek situated about half a mile to the west of Wigmore Creek. This deposit was stated to have afforded assays of 12 dwt. of gold per ton, but a general sample taken by the writers gave negative results for both gold and silver. A sample taken from a definite band carrying pyrite, arsenopyrite, and iron-oxides also yielded negative results. On the other hand, that gold does occur in extremely small quantities in this deposit was shown by one or two minute "colours" having been obtained on panning off a dish of the oxidized disintegrated material.

A siliceous-sinter terrace, from which a sample for assay was collected, occurs as a capping on a small hill 26 chains to the west of Trigonometrical Station U. This material afforded no trace of gold or silver.

CHAPTER X.

EXAMINATION OF FLUVIATILE GRAVELS FOR THE LOCATION OF POSSIBLE MINERAL-BEARING AREAS.

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Introduction.

In the preceding chapters of this bulletin the nature, position, and extent of the main mineral-bearing areas occurring within the Coromandel subdivision have been described. The notes and tabulations of the present chapter are presented mainly with the intention of assisting the prospector in operating beyond the limits of the well-known mineral-bearing centres.

In the traversing of the various watercourses, with the primary object of mapping the country both geologically and topographically, opportunity was afforded to carry on conjointly a preliminary prospecting for minerals of economic value. An expert mining prospector attached to each field party examined the débris of the banks and beds of the streams by the ordinary dish-concentration methods. While the possible occurrence in the concentrates of minerals other than gold was never overlooked, the problem over the greater portion of the area resolved itself into the determination of the presence or absence of the metal named.

It may be here pointed out that the country examined gives no evidence of glaciation, with the attendant transference of rock-material from one watershed to another, such as obtains in many of the goldfields of the South Island of New Zealand. The determination of the presence of gold in the débris of the stream is therefore significant, and the deduction can almost with certainty be drawn that the metal has been derived within the confines of the stream-valley; whether or no it occurs in payable quantity is, of course, quite another question. The negative evidence, however, as to the existence of gold as revealed by the rather rough dish-concentration methods, while in the main significant, cannot for obvious reasons be regarded as infallible.

In order to economize space and to afford a more ready reference, the results are here presented in tabulated form, and an asterisk has been inserted where references have been made to a locality elsewhere in this report. Branch creeks are referred to as right or left in the true sense—that is, according as they enter the main drainage-channel from the right or from the left of the observer, looking down the main valley; the prospector is often accustomed to regard branch creeks in the opposite sense. Where several branch creeks occur they have been numbered to correspond with the numbers inserted on the plan. Creeks not mentioned in the following lists have not been specially prospected.

Colville and Moehau Survey Districts.

General Statement.—The streams of this area drain for the most part areas consisting of old sedimentary rocks, which in many cases are intersected by dykes and sheets of intrusive rocks. The veins which have been located, occur in close proximity to the intrusive rocks. The prospects of ore-deposits of economic importance being discovered in this locality are certainly not encouraging.

Results of Prospecting Operations.

Stream.	Detrital Gold in Débris.		Quartz Veins located.			Remarks.
	Description.	Position.	Description.	Position.	Enclosing Rock.	
			Streams flowing to the Western Coast-line.			
Bronlund ..	Nil	..	..	..	..	Little or no quartz.
Ohinewai ..	..	..	..	..	..	* Contains boulders of vuggy quartz. (See page 109.)
Ongahi ..	..	..	..	..	..	* See page 109.
Sorry Mary ..	..	..	Small vein	$\frac{1}{4}$ mile from mouth	Contact of argillite and porphyrite	* See assay, page 108.
Hope	A few "colours"	..	Vein probably of large size	$1\frac{1}{4}$ miles from mouth	Ditto ..	* See assay, page 108.
Waiaro ..	..	..	..	..	..	Little or no quartz in stream-débris.
			Streams flowing to the Eastern Coast-line.			
Holland ..	Nil	..	..	..	..	
Stony Bay—						
Left branch ..	"	..	..	..	..	Quartz from vein not located; said to occur on ridge.
Right branch ..	"	..	6 in. vein ..	..	Argillite ..	Old workings.

Harataunga Survey District.

General Statement.—A glance at the maps accompanying the report will show the disposition of the rocks forming the area Veins occur in the old grauwacke and argillites, and in the overlying Tertiary igneous rocks both of the "First" and "Second Periods."

The propylitic andesites of the "First Period" are the most favourable for the existence of metalliferous veins, while the rocks of the Beeson's Island Series ("Second Period"), which form coastal belts both on the eastern and western sides of the peninsula, appear to be singularly devoid of auriferous veins.

The following results indicate that gold occurs in the débris of many of the drainage-channels. The auriferous veins which have already been located and worked by the prospector and miner have in no case returned sufficient gold from the small "pockets" of rich ore encountered to cover the cost of its production, nevertheless the further prospecting of certain areas described in a previous chapter (page 109) would appear warranted.

Results of Prospecting Operations.

Stream.	Detrital Gold in Debris.		Quartz Veins located.			Remarks.
	Description.	Position.	Description.	Position.	Enclosing Rock	
			Streams flowing to the Western Coast-line.			
Kairaumati ..	..	..	Small vein	$\frac{1}{4}$ mile from mouth	Argillite ..	..
" ..	..	.. ..	Quartz formation	On ridge at head of stream	Andesite ..	Old workings.
.. ..	..	..	Vein ..	$\frac{1}{2}$ mile from mouth	" ..	..

Results of Prospecting Operations—continued.

Stream.	Detrital Gold in Débris.		Quartz Veins located.			Remarks.
	Description.	Position.	Description.	Position.	Enclosing Rock.	
			Streams flowing to the Western Coast-line—continued.			
Umangawha—						
Ngakuku (Tributaries of Umangawha)	Colours of gold. Creeks drain a known auriferous area	..	Veins 6 in. to 2 ft. wide	Near head ..	..	* See assays, page 110.
"		..	Vein 6 in. to 1 ft. wide	At head ..	..	* See assay, page 110.
White Star		..	..	..	..	* See reference to White Star Mine, page 110
Barney		..	2 in. vein	Near junction	Argillite ..	..
"		..	Quartz formation	..	..	Assay, 8 gr. gold, 15 gr. silver, per ton.
"		..	6 in. vein	1 mile above junction	Contact of argillite and andesite	..
Sutton		..	3 ft. vein	¾ mile above junction	Argillite ..	Assay, 16 gr. gold, 16 gr silver, per ton.
Anthony ..	Nil	..	..	..	..	Little or no quartz.
Tawhetarangi ..	"	..	..	..	..	" "
			Streams flowing to the Eastern Coast-line.			
Taylor ..	Nil	..	Small vein	½ mile from mouth	Andesite ..	..
" ..	..	..	Vein 10 ft. 12 ft.	¾ mile from mouth	" ..	
Blind	A few "colours"	10 chains from mouth	Vein 15 in.	20 chains from mouth	" ..	Old prospecting-pits.
"	..	..	Vein 3 in. to 4 in.	10 chains from mouth	" ..	..
Big Sandy Bay ..	A few "colours"	..	..	..	..	Old workings. Jay Gould Claim, &c.
Tangiaro ..	"	..	"Silver lode"	1¼ miles from mouth	Andesite ..	See description and assay. page 109.
" ..	..	..	Vein 3 ft.	2 miles from mouth	" ..	..
Eel	Nil	..	..	..	..	Shows barren chalcedonic quartz.
Kerr	"	..	..	..	..	..
Portugese Bay ..	"	..	..	..	..	..
Waikawau ..	..	..	..	..	..	..
Waikanae ..	"Colours" ..	½ mile from mouth	Small vein	½ mile from mouth	Andesite ..	..
" ..	..	..	18 in. vein	Ditto ..	" ..	..
Gisborne ..	"Colours" ..	½ mile from mouth	..	..	..	Veins up to 2 in. No gold by crushing and panning.
Matamatahararakeke	Coarse "colours"	1 mile from mouth	16 in. vein	1 mile from mouth	Andesite ..	* See assay, page 110.
Ditto	..	..	Small vein	1¼ miles from mouth	" ..	..
Sandy Bay ..	..	..	..	..	..	..
Waihirere ..	Nil	..	..	..	..	Shows no quartz.
Whareroa ..	"Colours" ..	3 miles above mouth	Small vein	3¼ miles from mouth	Argillite ..	..
" (A) ..	" ..	For ½ mile ..	Vein ..	½ mile from junction	Andesite ..	Blue flinty quartz. No gold.
" (B) ..	" ..	For ¼ mile ..	4 in. vein	¼ mile from junction	Argillite ..	Old workings.
Mataiterangi* ..	..	..	Pug seam	2½ miles from mouth	" ..	Gives gold by panning.
" (See page 111.)	..	..	2 in. vein	Ditto ..	" ..	..
"	..	..	10 ft. vein	3 miles from mouth	Andesite ..	No gold by crushing and panning.
"	..	..	2 ft. 6 in. vein	3½ miles from mouth	" ..	Old workings. No gold by crushing and panning.
"	..	..	6 ft. vein ..	3¾ miles from mouth	" ..	Assay, nil.
..	..	..	9 in. vein	4 miles from mouth	" ..	..

Results of Prospecting Operations—continued.

Stream.	Detrital Gold in Débris.		Quartz Veins located.			Remarks.
	Description.	Position.	Description.	Position.	Enclosing Rock	
			Streams flowing to the Eastern Coast-line—continued.			
Mataiterangi (A)	7–8 "colours"	Just above junction	5 ft. vein..	10 chains above junction	Argillite ..	Assay, nil.
„ „	..	..	6 in. vein	Ditto ..	„ ..	7 to 8 "colours" by crushing and panning.
„ (A 1)	..	..	4 ft. vein..	..	..	A few "colours" by crushing and panning.
Mangatu* ..	A few fine "colours"	1 mile above junction	4 ft. vein..	75 chains above junction	Andesite tuff	..
„ (See page 110.)	..	..	6 ft. vein..	85 chains above junction	„	By dish, 4 or 5 "colours." (See assay, page 110.)
„	..	..	Small vein	95 chains above junction	Quartz andesite	Gives a few "colours" by crushing and panning.
„	..	..	3 ft. 6 in. vein	1¼ miles above junction	Andesite ..	No gold by crushing and panning.
„	..	..	A few small veins	To head of creek	..	Ditto.
Wairakau ..	Nil ..	..	..	..	..	..
„ (A) ..	"Colours" ..	For ¾ mile ..	6 in. vein	¾ mile above junction	Andesite ..	Old workings.
Omoho ..	..	..	½ in. vein	1¾ miles above junction	„ ..	Gives no gold on crushing and panning.
„ ..	..	..	Two 3 in. veins	Ditto ..	„ ..	Ditto.
„ (A) ..	"Colours" ..	..	"Exalt" leader	..	Argillite ..	* See reference, page 111.
Mangakotukuku	..	..	3 in. to 6 in. veins	..	Andesitic tuff	Give "colours." Old workings.

Coromandel Survey District.

General Statement.—The Coromandel Survey District covers a greater extent than any other survey district in the subdivision, and contains, with the exception of the Kuaotunu Goldfield, all the old-established mining centres of the area considered in this bulletin.

The auriferous-quartz veins are here associated with (*a*) the basement stratified rocks, (*b*) the Tertiary volcanic rocks of the "First Period," (*c*) the Tertiary volcanics of the "Second Period."

The veins occurring in the main range in the vicinity of Tokatea Hill and Saddle, and in portions of the Tiki, Matawai, and Manaia areas, are referable to the old rocks (*a*), while those of the Hauraki, Kapanga, Success, Preece's Point, and Opitonui Mines and their vicinities intersect to the greatest depths yet exploited only the volcanics (*b*). The coastal belt on the western side of the peninsula consists of volcanic rocks of the "Second Period" (Beeson's Island Series) (*c*)—principally breccias and agglomerates—and is certainly non-auriferous, but to the east of the divide the altered lavas and tuffs of this same series contain the auriferous veins of the Owera and Moewai Claims (page 131).

The "dish prospects" of the débris of the streams incising the ascertained mining-areas present no fresh significance, but the results of prospecting operations beyond these limits are of value.

Results of Prospecting Operations.

Stream.	Detrital Gold in Débris.		Quartz Veins located.			Remarks.
	Description.	Position.	Description.	Position.	Enclosing Rock	
			Streams flowing to the Eastern Coast-line.			
Harataunga ..	..	..	1 in. vein	5 miles from mouth	Andesite ..	Gives gold on crushing and panning.
„	Creeks drain a proved auriferous area	..	1 ft. vein..	Ditto ..	„ ..	Ditto.
„		..	4 ft. to 2 ft. quartz formation	„ ..	„ ..	„
„		..	4 in. vein	„ ..	„ ..	Nil.
„		..	3 in. vein	„ ..	„ ..	„
„		..	1 ft. vein..	5¼ miles from mouth	„ ..	Gives coarse "colours" on crushing and panning.

Results of Prospecting Operations—continued.

Stream.	Detrital Gold in Débris.		Quartz Veins located.			Remarks.
	Description.	Position.	Description.	Position.	Enclosing Rock.	
		Streams flowing to the Eastern Coast-line—continued.				
Kopurukaitai ..	..	..	9 in. vein	2 miles above junction	Andesite ..	Old workings.
„ Branch (*a*)	"Colours" ..	For 30 links	..	..	..	Gold traced to a slip.
„ „ (*b*)	..	..	Small vein	..	Andesite ..	Old workings.
„ „ (*c*)	..	..	„	..	„ ..	„
„ „ „	..	..	2 ft. 6 in. vein	..	„ ..	..
„ „ (*d*)	..	..	1 ft. vein ..	¼ mile above junction	„ ..	..
„ „ „	..	..	„ ..	½ mile above junction	„ ..	..
„ „ „	..	..	6 in. vein	At head ..	„ ..	See assay, page 125.
„ „ „	..	..	„	10 chains from head	„ ..	„ „
„ „ (*e*)	..	..	1 ft. vein ..	Near head ..	Coarse andesite breccia	..
Waikoromiko ..	Creeks drain a proved auriferous area.	..	18 in. vein	¼ mile above junction	Andesite ..	Gives gold on crushing and panning.
„ ..		..	1 ft. vein ..	Ditto ..	„ ..	Mineralised; no gold.
„ ..		..	6 in. vein	„ ..	„ ..	„ „
„ ..		..	1 ft. pug vein	„ ..	.. ..	„ „
„ ..		..	3 in. rusty vein	30 chains above junction	„ ..	Gives gold on crushing and panning.
„ ..		..	2 in. vein	½ mile above junction	.. ..	Ditto.
„ ..		..	3 ft. vein ..	Ditto ..	.. ..	„
„ ..		..	1 ft. vein ..	¾ mile above junction	„ ..	„
Waikoromiko (*a*)		..	Small vein	..	„ ..	Old workings; 1 "colour" per dish on crushing and panning.
„ (*b*)	..	..	Small veins	..	„ ..	Give no gold on crushing and panning.
„ „	Good prospect of gold	½ mile above fork	..	..	..	In the alluvium, here 6 ft. deep.
„ (*c*)	"Colours" ..	To head ..	..	..	Andesite ..	Traced to old workings.
„ (*d*)	„ ..	„ ..	..	..	„ ..	„
„ (*e*)	Coarse "colours"	For 5 chains	..	.	..	Traced to heavy surface débris.
„ „	1 "colour" ..	8 chains above fork	..	..	..	From a pot-hole.
„ „	..	..	5 ft. vein ..	10 chains above fork	Andesite ..	Shows no gold.
„ „	..	..	18 in. vein	Ditto ..	.. ..	„
„ „	..	..	½ in. rusty vein	15 chains above fork	.. ..	Old workings.
„ (*f*)	"Colours" ..	To head ..	..	..	..	Traced to heavy surface débris.
„ (*g*)	Trail of gold ..	„ ..	..	..	..	Traced to old workings on 1 ft. reef.
„ (*h*)	„ ..	„ ..	..	..	..	Traced to an old drive.
„ (*k*)	..	..	..	..	..	Old workings of Beresford Mine.
„ (*m*)	Trail of coarse gold	For ½ mile ..	..	..	..	Traced to a slip.
„ „	Trail of gold ..	10 chains above last	..	..	..	Traced to a pug seam.
„ „	„ ..	For 10 chains above last	..	..	..	Traced to old workings.
„ „	„ ..	10 chains above last	..	..	..	Traced to old drive on pug seam.
„ „	„ ..	For 3 chains above last	..	..	.	Traced to pug seam in old drive.
Pakore ..	Nil ..	..	..	..	..	..
Te Pungapunga	.. ..	..	..	..	..	Shows no trace of gold.
Waitekuri (A) ..	..	..	Small vein	Just above fork	..	Gives gold on crushing and panning.
. ..	"Colours" ..	15 chains above the fork	..	..	..	..

Results of Prospecting Operations—continued.

Stream.	Detrital Gold in Débris.		Quartz Veins located.			Remarks.
	Description.	Position.	Description.	Position.	Enclosing Rock.	
Streams flowing to the Eastern Coast-line—continued.						
Waitekuri (A) ..	"Colours" ..	½ mile above fork	..	..	..	..
" ..	" ..	50 chains above fork	..	..	..	..
" (A 1)	Coarse "colours"	At junction ..	Two small veins	..	..	Show no gold.
" (B) ..	..	..	Small veins	¾ mile above fork	Andesite ..	..
" ..	..	..	Flinty vein	1 mile above junction	" ..	..
Waingaro ..	Nil	..	..	..	..	1¼ miles from mouth. Andesite contains quartz showing pyrite; no gold.
Opitonui ..	..	..	..	..	..	* Shows no gold in creek above outcrop of Opitonui Reef. (See page 129).
Owera	Nil	Above Owera branch (A)	..	..	..	* See reference to Owera Mine, page 132.
Mahakirau ..	2 fine "colours"	3¾ miles above junction	..	..	..	* See references to Specimen Terrace, &c., and assays, page 131.
" ..	1 "colour" ..	4¼ miles above junction	..	..	..	
" ..	1 coarse "colour"	4½ miles above junction	..	..	..	
Howell ..	Nil	..	..	..	..	No quartz.
Mill's; driving	"	..	..	..	..	"
Driving ..	"	..	..	..	..	A little quartz.
Hooker ..	"	..	..	..	..	"
Waitakatanga ..	1 "colour" ..	..	..	..	..	In middle course of main left branch.
Day Dawn ..	2 fine "colours"	At junction	..	..	..	* See reference, page 130.)
Sparrow ..	Nil	..	..	..	..	..
Hooker, south ..	"	..	..	..	..	Shows some quartz.
Waiparu ..	..	..	..	..	..	* Ditto. (See page 130.)
Battery ..	6 "colours" ..	At junction	..	..	..	..
" ..	10 " ..	¼ mile above junction	6 in. vein	30 chains above junction	..	* See assays, page. 130
" ..	..	..	20 ft. vein	..	..	* Old workings. (See assay, page 130.)
McIsaacs ..	1 "colour" ..	½ mile above junction	..	..	..	* Abundance of quartz from large "blows" on ridge. (See page 130.)
" ..	..	..	9 in. vein	1½ miles above junction	Andesite ..	Assay, 4 gr. gold, 1 dwt. 1 gr. silver, per ton.
Rocky ..	1 "colour" ..	1 chain from junction. No trace of gold above this point	..	..	..	..
Jubilee ..	Fair "prospects" of gold	..	..	..	..	* See reference, page 131.
Streams flowing to the Western Coast-line.						
Paparoa ..	Nil	..	..	..	..	Little or no quartz.
Whaiwango ..	"Colours" ..	As far as junction of Little Paul's Creek	..	..	..	Very little quartz.
Little Paul's ..	Good prospects	To headwaters	..	..	..	* See reference, page 126.
Kikowhakarere	Nil	..	..	..	..	..
Streams draining Coromandel Valley	..	..	..	..	..	* Proved auriferous area.
Waiau ..	No gold in head-water branches	..	..	..	..	Little quartz above Matawai junction.
Matawai ..	Good dish prospects	½ mile above junction	..	..	..	* See reference, page 128
Tiki	..	..	..	..	..	* " page 126.
Pukewhau ..	..	..	..	..	..	* " page 128.
Awakanae ..	Nil	..	..	..	..	No quartz.
Mill	"	..	..	..	..	"

Results of Prospecting Operations—continued.

Stream.	Detrital Gold in Débris.		Quartz Veins located.			Remarks.
	Description.	Position.	Description.	Position.	Enclosing Rock.	
		Streams flowing to the Western Coast-line—continued.				
Manaia ..	1 "colour" ..	Just below Taurarahi junction	..	..	..	* See reference to Golden Hill, page 129.
,, (A) ..	1 coarse "colour"	$\frac{1}{4}$ mile above fork	..	..	..	* See page 129.
,, (B) ..	2 or 3 fine "colours"	Just above fork	..	..	..	
Taurarahi ..	1 to 6 "colours" of coarse gold	For $\frac{3}{4}$ mile above junction	..	..	..	* See reference to Leading Wind Mine, page 129.
,, ..	"Colours" ..	For $\frac{3}{4}$ mile above last	..	..	..	Last "colour" at junction of a right-hand branch(C).
Tupa	Nil	..	..	..	..	No quartz.
Kirita ..	,, ...	..	..	..	..	,,

Otama Survey District.

General Statement.—The Otama Survey District includes within its boundaries the Kuaotunu mining centre and the claims of Materangi and Murphy's Hill.

The auriferous veins of Kuaotunu occur essentially in the stratified rocks (Manaia Hill Series), but in places intersect also a thin capping of "Beeson's Island" volcanics; the occurrences at Materangi are associated altogether with the volcanic rocks of this series, and are closely related to the Owera and Moewai veins of the Coromandel Survey District.

Siliceous-sinter deposits are abundant on the Kuaotunu Peninsula, and also on the rhyolitic area lying to the eastward of Whitianga Harbour; those of Black Jack Hill, Kuaotunu, contain traces of gold and silver, but are of no economic value.

Results of Prospecting Operations.

Stream.	Detrital Gold in Débris.		Quartz Veins located.			Remarks.
	Description.	Position.	Description.	Position.	Enclosing Rock.	
Otangaru ..	"Colour" ..	..	..	..	..	..
,, (A) ..	2 or 3 "colours"	15 chains from junction	..	..	..	..
Mapauriki ..	Nil	..	..	..	..	..
,, (A) ..	1 or 2 "colours"	Just above junction	..	..	..	..
Streams of Kuaotunu Valley	..	..	..	..	..	Proved auriferous area.
Otama ..	1 "colour" ..	$\frac{1}{4}$ mile from mouth	..	..	..	Upper portion not prospected.
Stewart ..	Nil	..	..	..	..	..
Kohurahorao ..	1 "colour" ..	Near head ..	..	..	..	Formation grauwacke.
Waitaia ..	,, ..	$\frac{1}{2}$ mile from mouth	..	..	..	Old workings in valley are said to have yielded specimen stone.
,, ..	,, ..	50 chains from mouth	..	..	..	
Woodcock ..	Nil	..	..	..	..	Boulders of siliceous sinter, but no vein-quartz.
Whauwhau ..	..	..	..	..	..	* See reference, page 137.
Akeake ..	Nil	..	..	..	..	..
Ngarahutonoa ..	"Colours" ..	..	..	..	..	* See reference to Moewai Mine, page 132.
Wade	1 "colour" ..	Near head ..	..	..	..	* Creek-débris; said to have yielded loose specimens of native bismuth. (See page 104.)
Purangi ..	Nil	..	..	..	..	..
Wigmore ..	"Colour" ..	..	..	..	Siliceous-sinter deposit; rhyolite	See page 137.

CHAPTER XI.

RÉSUMÉ OF THE ECONOMIC POSSIBILITIES OF THE COROMANDEL SUBDIVISION.

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Introduction.

The Coromandel subdivision, comprising an area of 307·89 square miles, while primarily owing its economic importance to the occurrence of gold-silver veins, is not solely dependent upon its mining industry. Of the natural resources other than minerals and rocks, the lands adapted for agricultural and pastoral purposes must be accorded first place. A considerable extension of the area at present employed for the depasturage of sheep and cattle is to be expected as the result of the deforesting of the lower slopes of the hilly country bordering the alluvial flats. The results which should attend the systematic development of these lands are likely to more than compensate for the inevitable decline in the export of timber and kauri-gum. Of the marketable timber the estimated amount of kauri now growing in the area does not exceed 10,000,000 superficial feet; other timber-trees of value for special purposes occur to lesser extent, but the area covered by lighter bush available for fuel is still considerable. The amount of kauri-gum which can yet be won from the area cannot be estimated, but it is probably less than that already exported.

The mineral resources of the subdivision are naturally those which more particularly fall within the scope of this report. These may be reviewed under the headings—

(*a.*) The future prospects of gold-silver mining.
(*b.*) Metalliferous deposits other than gold-silver veins.
(*c.*) Building and ornamental stones.
(*d.*) Limestone.
(*e.*) Coal.

(*a.*) The Future Prospects of Gold-silver Mining in the Coromandel Subdivision.

The attempt to forecast the future of any goldfield is not an easy task, and it will be readily conceded from a perusal of the preceding pages that it is almost impossible to predict with any degree of accuracy the future yield of the Coromandel Goldfield.

The veins of the main mining centre (Coromandel) and its near vicinity are as irregular in their gold-content as those of probably any goldfield in the world. Taking any particular mine of this area, it is seldom or never practicable to estimate the ore-reserves of a given vein, even if development-work be kept well in advance of the actual getting of the ore. In the Kuaotunu centre ore-shoots of fairly uniform value and of considerable extent were encountered, but, of even these shoots, those already worked at a level of about 500 ft. from the outcrop were found to terminate with almost the same abruptness as did most of the higher-grade bonanzas of the Cormandel centre.

The experience of the past as outlined in the historical section of Chapter II is sufficient guarantee for the statement that the Coromandel Goldfield is very far from depleted of its bonanza ores. Since, however, the actual surface of the ascertained auriferous areas has been time and again searched by the prospector, the location of new veins and ore-shoots must become more difficult and expensive than heretofore Seeing that all the great bonanzas hitherto discovered on the field occurred within a depth of 800 ft., and most of them within a depth of 400 ft. of the present surface, it is probable that most of the bonanzas yet to be won will be derived from this same vertical zone in areas which are, owing to concealment of outcrops, as yet unprospected.

In connection with the Hauraki–Kapanga–Tokatea belt, the most productive yet ascertained, it is almost certain that veins comparable in richness with those already exploited await discovery in unexplored parts of the area. As to the extent of this particular belt, McKay* writes, " How far this is a distinctive belt or zone of mineralised country has not, towards the south, been determined, as no mine-workings are extended under Kapanga Flat, and the volcanic rocks *in situ* are not seen at the surface." Prospecting of this andesitic area underlying Kapanga Flat and the Township of Coromandel is rendered difficult owing to the fact that alluvial deposits extend to a depth of over 100 ft. below sea-level. The sinking of a few boreholes might be expected to afford valuable information as to the character and alteration-phases of the country rock existing in this locality. Suggestions respecting future developments have been submitted in connection with the detailed descriptions of some of the individual mines on this belt.

In regard to the various other auriferous belts and isolated areas, further discoveries in the upper zone may from time to time be expected. The heavy overmantle of surface débris, however, together with the density of the forest undergrowth, conceals rock-outcrops and renders the location of auriferous veins almost as much a matter of chance as of expert prospecting. It may here be stated that the detailed explorations carried out by the present survey, force the writers to the conclusion that future gold-discoveries in the Coromandel subdivision will be located in or near the already ascertained auriferous areas, and consequently that little further areal extension of these goldfields can be expected.

The foregoing remarks, it will be observed, apply in the main only to the upper zone—that lying within, say, 800 ft. of the surface, irrespective of topographical features. As regards the prospects of obtaining payable ore from below this zone, mining operations have as yet afforded few criteria. In the Kapanga Mine shaft-sinking and boring has attained a depth of over 1,200 ft. in the andesitic rocks. Although the limited amount of work done at the 940 ft. and 1,000 ft. levels has so far proved unremunerative, the prospects reported from here and from the boring operations below these levels are not discouraging. As already pointed out, the existence of an older land-surface at a depth of 940 ft. in this mine implies the possibility of ore-deposition in the underlying andesitic rocks at a period prior to the accumulation of the vein-bearing andesites of the upper zone, and may therefore be regarded as a rather hopeful feature. Should such ore-deposits be proved to exist in the Kapanga Mine, similar conditions may be expected in the Hauraki and other mines on this andesitic belt, since this " deep ground " evidently extends west to the shores of the Coromandel Harbour.

While, however, payable ore may be expected to exist below the 800 ft. zone in favourable horizons of propylitic andesites, the conditions obtaining in Cripple Creek (U.S.A.), and other districts of similar geological structure to the Coromandel field, suggest that the ore-shoots at the deeper levels will be found less numerous and of lesser dimensions than those of the upper zone.

A consideration of deep-level mining in the Coromandel Goldfield is, moreover, concerned with the prospects of payable ore occurring in the old stratified rocks, which are exposed over relatively great areas. Furthermore, even in areas where andesitic rocks have been proved or may be expected to extend to considerable depths, the sedimentaries must eventually be encountered. Areas covering the old crateral vents, which may be considered to exist in certain undetermined localities, would, however, prove exceptions to this general statement.

In only two localities in the subdivision can it be affirmed that remunerative returns have been obtained from mining in the basement rocks. These localities are Tokatea Hill and Kuaotunu, the ore-shoots in both cases being mined from the upper zone. At Tokatea the veins were associated with the

* C.–9, 1897, page 47.

interstratified fine-grained acidic tuffs and tufaceous mudstones rather than with the ordinary argillites and grauwackes. They, moreover, evidently had upward extension into a capping of andesitic rocks not long since removed by denudation. These veins became impoverished with depth, and at the lowest level, 900 ft. below the vein-outcrop or 647 ft. above sea-level, were found to be practically valueless. At Kuaotunu the payably auriferous veins were almost entirely associated with the Jurassic grits, grauwackes, and argillites, but the principal vein—the Try Fluke—intersected at one locality a remnant of the andesitic capping. The ore-shoot in the vein mentioned extended from the outcrop to a depth of about 450 ft., or 200 ft. above sea-level. The ore-shoot of the Waitaia vein, already proved for some 350 ft. in vertical extent, still persists below the lowest adit, which is, however, 300 ft. above sea-level.

The two cases cited are evidence that payable gold-silver veins may exist in the basement stratified rocks, and in lithologically different types of these rocks. It would nevertheless appear that proximity to the surface or to the contact of the overlying volcanic accumulations has constituted no negligible factor in the precipitation of the gold-silver content of these veins.

On the whole, the prospects of deep mining in the basement stratified rocks do not appear to be bright, and the comparisons often drawn, by mining-men, between this goldfield and certain other deep-level goldfields, are scarcely admissible. As regards geological conditions, probably the Coromandel field has its nearest analogue in portions of the Dacian goldfield of south-western Transylvania. "At Vulkoj," in this field, says Posepny,* "the older and deeper quartzose rock carries little ore, while gold abounds in the overlying andesites. Several mines of the Dacian gold district have encountered in depth the stratified rocks through which the eruptives (Tertiary andesites, &c.) came, and the result has generally been disastrous to the miner, the ore-veins having either ceased entirely or become pinched to barren fissures." Since, however, the conditions governing the deposition of most gold-silver ores cannot yet be regarded as very clearly comprehended, a definite pronouncement as to whether or no pay-ore exists at any considerable depth must be left to actual mining exploration.

Within the subdivision, the Kuaotunu or Tokatea areas, having afforded large and payable shoots in the upper zone of the stratified rocks, may be the first to receive attention. At Kuaotunu the further exploitation of the ore-shoot of the Waitaia Mine below the present levels will be followed with interest. Furthermore, there is some evidence that the Jurassic grits and argillites, which at the existing levels form the country rock of the Try Fluke vein-system, are at no great depth underlain by the Tokatea Hill Series, with its interstratified tuffs and mudstones. The sinking of one or two boreholes on the eastern side of the Bald Spur might therefore be expected to afford valuable information regarding the effect of this probable change of rock-formation on these strong fissure-veins, which, in the upper levels, have yielded such substantial returns. In this connection, the remarks of McKay, who examined the Kuaotunu field when active mining was in progress, may be quoted. After reviewing the evidence, this investigator concludes thus: "The facts at Kuaotunu appear to be in favour of the supposition that other shoots of gold may be found at levels below those yet reached in the Try Fluke and Kapai-Vermont Claims and other claims along the same line of reef."

In the reports of Murray,† McKay,‡ Park,§ and Maclaren,‖ cited below, will be found further expressions of opinion regarding mining below the upper zone in this subdivision.

In conclusion, the writers are of opinion that Coromandel will long be classed among the goldfields which afford ample scope rather for the speculator, who is prepared to take risks in the hope of reaping large profits, than for the investor who expects a regular percentage of profit on capital employed. The field can hope for little from improved metallurgical processes, since it possesses no workable low-grade ore-bodies. In view, however, of the heavy expense at present connected with pumping, winding, and underground exploration, every device calculated to lower the cost of motive power or to cheapen in any other way the existing methods of mining must be counted a decided advantage.

* F. V. Posepny: "The Genesis of Ore-deposits," Trans. Am. Inst. Min. Eng., vol. xxiii, 1893. Reprinted by same Institute in "The Genesis of Ore-deposits," 1902, page 88. † Murray: C-6, 1894, page 4. ‡ McKay: C-9, 1897. § Park: "Geology and Veins of Hauraki Goldfield, 1897"; "Notes on the Geology of The Kuaotunu Goldfield," Trans., vol. xxvi, page 360. ‖ Maclaren: C-9, 1900.

(b.) Metalliferous Deposits other than Gold-silver Veins.

In previous chapters of this bulletin reference has been made to the occurrence of ores of lead, copper, antimony, and bismuth. The prospecting operations of the past, however, have not been successful in locating deposits of any of these ores in payable quantities.

The galena-chalcopyrite lode of the Petote and Tiki Creeks, though in the present mine-workings rather small and lenticular, may yet prove of some economic value. A huge boulder of this ore discovered some years ago in Tiki Creek would indicate that the veins may at some undiscovered point attain greater dimensions than at the localities worked.

Ore containing a high percentage of antimony in the form of stibnite has been found as boulders in the little-explored Upper Mahakirau Valley. A picked sample from the veins already located gave on analysis only 9·66 per cent. of the metal.

Metallic bismuth was found in the débris of Wade Creek (Mercury Bay), but the source of the erratics has not yet been located.

(c.) Building and Ornamental Stones.

Building and ornamental stones occur at two widely separated localities in the subdivision. The quartz diorite of the western flank of Mochau Range is the most valuable of these stones, being almost equal to the best granites for architectural purposes and for heavy masonry-work.

Stones of very different textural character are afforded by the pumiceous rhyolitic tuffs of Whitianga. One variety of these tuffs, a pinkish-grey rock, has well withstood the test of twenty-five years' service as wharf-piers and building-foundations. Another variety, resembling the white calcareous Oamaru stone, occurs in considerable abundance, and is of value for special purposes. The spherulitic rhyolite of Purangi may prove on exploitation to afford a handsome ornamental stone.

(d.) Limestone.

Since limestone is not known to occur elsewhere in the Hauraki Peninsula, the deposits of this rock exposed at Torehine and Branch Creek are of some commercial value.

At Torehine the limestone (containing 85·7 per cent. $CaCO_3$), though of somewhat limited extent, is easily accessible, and likely to be employed for metallurgical purposes within the Hauraki goldfields. At Branch Creek, which, however, is situated some four miles from the sea-border, a much greater quantity of limestone is available than exists at Torehine.

(e.) Coal.

Coal is known to occur in association with the beds of the Torehine Series at several localities in the subdivision; but the limited extent and inaccessibility of the deposits precludes its being regarded as of any economic importance.

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